Towards a Streamed Holographic 3D Game Engine

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Abstract. *In this work-in-progress article we present our initial attempt in building a streamed 3D holographic game engine. Game streaming technology provides the opportunity to use cloud-based resources like advanced graphic processors to play computer games on low-cost end-user devices. Holographic games are a relatively new technology which provides a new way of experiencing multimedia and games but are currently a high-cost. Herein we present a prototype game streaming engine we have built that allows us to stream holographic games to consoles based on Peppers's Ghost pyramids which emulates a holographic display.*

Keywords. game engine, game streaming, holographic, pepper's ghost, computer games

1 Introduction

A game engine is a computer program that enables the development and management of all aspects and computing resources required to run a game (e.g., graphics, sound, user interface, scripts, events, data storage, networking, artificial intelligence, physics, etc.). The user of a computer game engine is a computer game programmer. In this work-in-progress paper we are on our journey to develop a game engine that would allow games to be (1) streamed over a network and (2) displayed on a holographic display device.

Game engines are complex systems consisting of numerous subsystems (see figure 1). Our objective herein is not to *reinvent the wheel* and reimplement all parts of a game engine from scratch, but to focus on two particular aspects of game engines which will allow us to achieve the above stated objectives: game streaming and holographic display of games.

Thus, we have chosen to use an existing game engine (namely UPBGE - a community based continuation of the Blender Game Engine[1] and extend it with: (1) a game streaming architecture, (2) a display transformation to allow display on a holographic display.

The rest of this paper is organized as follows: firstly in section 2 we provide an overview of game streaming technology. Then in section 3 we familiarize the reader with holographic display technology. In section 4 we describe the prototype system that we have developed. In the end in section 5 we draw our conclusions and provide guidelines for future research.

[1] For further information, see https://upbge.org/

2 Game Streaming

The advancement of technology allows most households to own at least one personal computer (PC). Such PCs can usually suffice when playing video games is considered, most modern games included. The key and the most observable element of enjoying a game is observing rich and smooth graphics provided by the game designers, especially when combined with smooth and fluid storytelling and game mechanics, provided by the games' developers and other artists. The most important building block of a PC, in the context of providing enjoyable graphics, is graphics hardware, i.e. external graphics cards (as opposed to on-chip integrated graphics hardware). The main problem in the domain of graphics cards is their price, which soared during the last decade, and made high-tier PCs almost unavailable to average targeted consumers in e.g. the EU, North America, or Far East. This obstacle, in turn, makes it harder for gamers, i.e. variously skilled players of games, to enjoy the full potential of games and their developed graphics.

With the advent of access to the Internet, and the increasing speeds available in increasingly large areas and portions of the world, e.g. access to high-speed optical fibre across the EU, an average user can rely more on the constant availability of information, and the speed of recovering it whenever needed. Constant availability of the Internet rendered music and video storage, such as a CD-ROM, a DVD-ROM, a BluRay disks, or a USB memory drive, or even a portion of a disk with stored music files, almost obsolete. Reliable access to the sources that provide multimedia files as streams of data shifted the focus of an average user, shifted the behaviour towards legal use of various types of multimedia, and created new habits when multimedia consumption is considered. Even though they are dispersed amongst many streaming services, a rich collection of music, movies, TV shows, cartoon series,

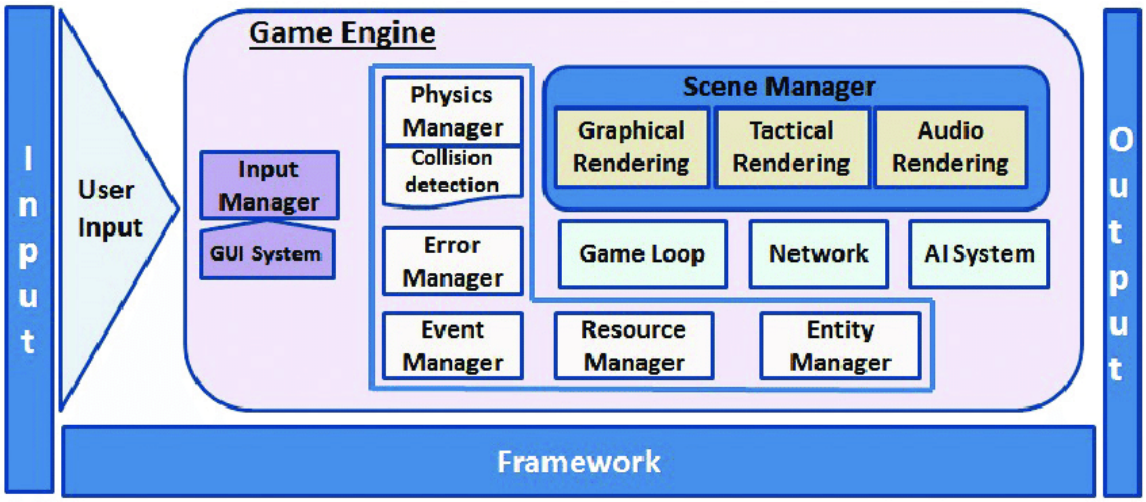

Figure 1: A game engine's architecture (Zarrad, 2018)

etc. is available in a matter of seconds to a great number of users throughout the world.

The trouble with streaming video games is that video games are an interactive type of multimedia entertainment. Videos and music can be streamed safely, but they are being streamed one way only: from the service provider to the user, and not much interaction is expected except for maybe starting a stream, pausing, moving the time line and other simple instructions. In streaming video games, the game is expected to behave according to the input of its player in real time. For example, if the player moves by pressing a key on the keyboard, the in-game character is expected to move almost instantly; if the player clicks on a menu item, the interface is expected to change accordingly; if the player's avatar is being attacked, or is found in a situation where speed is of the essence, the game is expected to react to the player's input almost instantly, etc. The described scenarios are only a few, a needle in a haystack of playing video games, that require almost instant reaction of the game – moreover, they require that the player receives an almost instant feedback that the game instantly reacted to the received player's input. Usually, establishing such a quick feedback loop is not a problem in PCs, but it does present a challenge in video game streaming services.

There is a caveat that should be addressed though. Not all games require feedback loops that are (as much as possible) instantaneous. Some games (usually single-player games) can be played with an occasional slight delay, because such a game, for example, does not rely on the speed of its player's reaction, or that particular feature is of low significance.

The benefit of combining the ideas of video games and multimedia streaming services is manifested in the opportunity to play video games without having necessarily to own the hardware that can run those video games. Usually, the time spent on gaming, i.e. playing video games, is only a fraction of the time spent on using the PC for other purposes. Therefore, owning hardware that will provide the resources for playing a video game can be expensive, especially when time, utility, and use are considered. On the other hand, a video game streaming service can be used whenever needed, and (in some cases) on virtually any device available, if the appropriate Internet speed and game-controlling hardware (e.g. a game controller, a keyboard, a mouse, a wheel, etc.) are at the player's disposal.

There are technologies and approaches that are used for further reducing the expected feedback loop duration, and providing smoother playing experience, such as predicting a player's move and rendering possible actions before they actually happen, or rendering only specific sets of pixels that change in consequent frames, etc. (Schatten et al., 2020)

Game streaming systems are usually complex and consist on numerous components that deal with various aspects of networking, game interaction as well as graphics rendering (see figure 2 for an example architecture based on virtual machines proposed by (Hossain et al., 2015)).

Many video game streaming platforms exist today (Greenwald, 2022), each of which uses a different method of providing games to be streamed, some of which are: NVIDIA GeForce NOW[2], Amazon Luna[3], Sony PlayStation Now[4].

The initial test case scenario for the holographic platform described in this paper will consist of a game that does not rely on the speed of its player, rather it will be used to showcase the possibilities of playing a game developed for, and played on, such a platform.

[2]For further information, see https://play.geforcenow.com
[3]For further information, see https://www.amazon.com/Luna/
[4]For further intofmation, see https://www.playstation.com/en-us/ps-now/

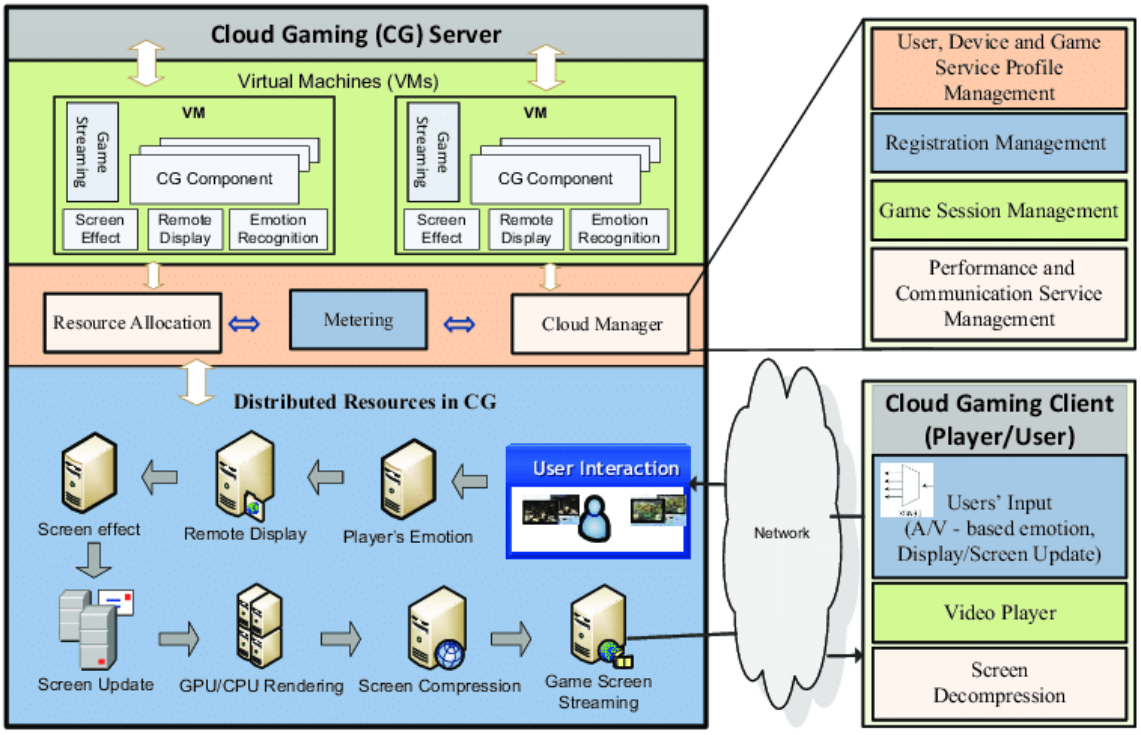

Figure 2: A game streaming architecture (Hossain et al., 2015)

3 Holographic Technology

A hologram is 3D visual display that is visible from all angles. At the time of writing there are a number of promising holographic technologies available (Blanche, 2022; Chang et al., 2018; Fadzli et al., 2022; Haleem et al., 2022; Li et al., 2022; Piliar, n.d.; Wang et al., 2022). From a commercial perspective, there are various technologies that will produce a similar effect.

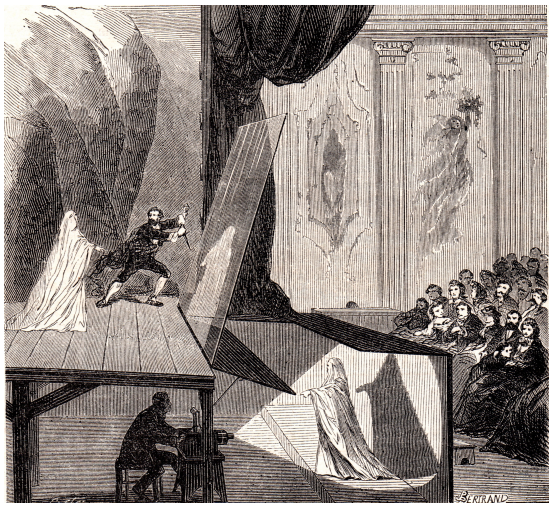

Figure 3: By Le Monde Illustré, Public Domain

One such technology are so called Pepper's Ghost images, after the English scientist John Henry Pepper (1821–1900) shown on figure 3. The basic idea behind this technology is to use a light display that emits an image on a reflective (usually transparent) surface which reflects the image and provides a holographic experience.

A common enhancement of the original system is to use a glass or acrylic four sided pyramid instead of just one surface, and place a display above the pyramid so that the holographic image is visible from all four sides of the pyramid.

On the other hand, voxel technology is based on producing an information that consists of volume and pixel. Pixels are physically created in space as floating objects. Displays that support such technology are called volumetric displays and stand for actual true holograms (Yang et al., 2015).

Holography based on fans are also drawing attention. The idea behind the technology is to transmit a light towards a running fan. Unless on a close proximity, one will not notice visually that a fan is spinning, however, transmitting a light on it will produce an effect of having floating objects from any distance (Prado Ortega et al., 2020).

4 Prototype Implementation

In order to provide a working proof-of-concept holographic we have designed and partially implemented a game engine for streaming holographic content. During design and implementation we have used multiagent systems (MASs) as a natural way of developing intelligent distributed systems. The architec-

ture of the system is shown on figure 4. Additionally, we have used a gaming console as a metaphor for the implementation. The system consists of a pool of existing game agents which comprise containers called cartridges that represent the games that are supported by the engine (implemented by actual game developers). Each cartridge is a microservice container (in our case Docker[5] container) which consists of a minimalized Linux operating system that includes a graphical user interface and a game engine (in our case UPBGE), the actual game implementation as well as a camera transformation that allows us to display the game on a holographic display based on Pepper's Ghost technology.

We have implemented this transformation in UPBGE by using a simple technique. In order to get the state of the 3D world for each of the four sides of the pyramid we have used four cameras which display the world in real time from four perspectives. Additionally, we have created a custom viewport that shows all four camera outputs on the same display at once, which allows us to use one display above the pyramid to show all four perspectives. The implementation of this script is shown in the following listing:

```
from bge import logic, render
camList = logic.getCurrentScene().cameras

cont = logic.getCurrentController()
own = cont.owner
camn = camList[ own[ 'camn' ] ]
cams = camList[ own[ 'cams' ] ]
camw = camList[ own[ 'camw' ] ]
came = camList[ own[ 'came' ] ]

a = render.getWindowWidth()
b = render.getWindowHeight()

x = int( ( a - b ) / 2 )
y = int( b / 4 )
z = int( b / 2 )

# setViewport( left, bottom, right, top )
camn.setViewport( x+y, y+z, x+y+z, b )
cams.setViewport( x+y, 0, x+y+z, y )
camw.setViewport( x+y+z, y, x+2*y+z, y+z)
came.setViewport( x, y, x+y, y+z )

camn.useViewport = True
cams.useViewport = True
camw.useViewport = True
came.useViewport = True
```

For example figure 5 shows the UPBGE interface for a simple world in which we have put an interactive 3D model of a dragon[6] on a simple plane. The dragon can be manipulated using the usual keyboard and mouse inputs in real time.

By using the script shown above, the world is rendered as shown on figure 6. As one can see, four cameras show the dragon from four sides (north, east, south, west) at the same time.

By using a transparent pyramid and placing the center of it in the center of the display by aligning the sides with the sides of the display, one can get a hologram-like appearance as shown on figure 7. In this way, any game implemented in UPBGE with the given transformation can be transformed in a holographic game. Of course, this transformation is not suitable for all existing games, but only for those for which a holographic display can or should be used. We envision that various new types of games, which make use of the holographic nature of the display in their core game mechanics can be implemented that go beyond games based on traditional non-holographic displays.

In addition to game agents, there are two other important types of agents: (1) game streaming agents as well as (2) videoconferencing agents. The gane streaming agents are envisioned as orchestrators. They get requests from clients that would like to play a game from the pool of available games, allocate resources in the could (which could be any orchestration platform like Kubernetes of Docker Swarm) and instruct a game agent to start it's cartridge as a container instance on the allocated end system. This allocation is considered a game instance in which an instance of a game agent directly communicates with an end-user's web based interface to which a game is streamed. The streaming is implemented by using XPRA[7] and a X11VNC[8] server which are contained in each game cartridge.

In addition to game streaming agents, videoconferencing agents are implemented as well that allow audiovisual and text communication between players (in multiplayer games for example) or live streaming of a players video and audio feeds (for live events for example). The game sgtraming agents instructs a videoconferencing agent to open an new room for each game that is being streamed and this new videoconference instance then directly communicates with the player's web based user interface. Videoconferencing is implemented using Janus WebRTC server[9].

In the end, the web based user interface features a VNC client that displays the streamed game and allows user interaction as well as a WebRTC client to allow for video and audio streaming.

All agents are implemented using Python, especially the SPADE platform (Palanca et al., 2020). The web based user interface is an adaptation of noVNC[10] with additional WebRTC client implementation in JavaScript.

[5]For further information, see https://www.docker.com/

[6]Available at https://3dmdb.com/en/3d-model/bge-dragon-20/1005315/?free=True&q=bge+dragon

[7]For further information, see https://xpra.org/

[8]For further information, see https://launchpad.net/ubuntu/+source/x11vnc

[9]For further information, see https://janus.conf.meetecho.com/

[10]For further information, see https://novnc.com/

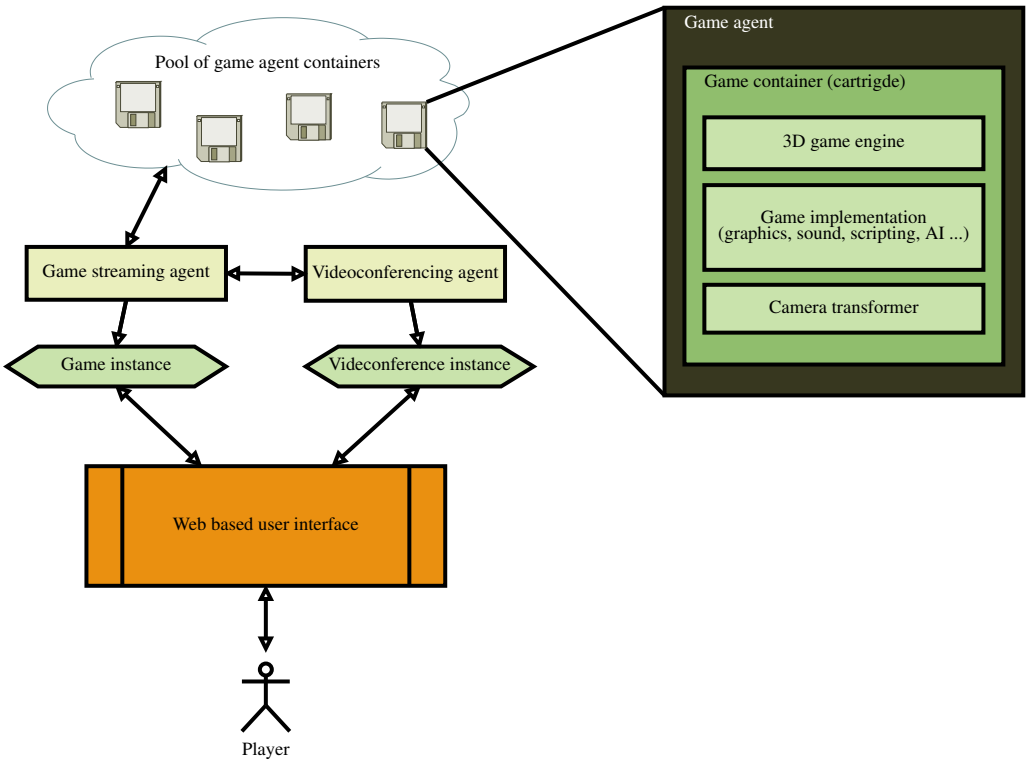

Figure 4: Prototype Architecture

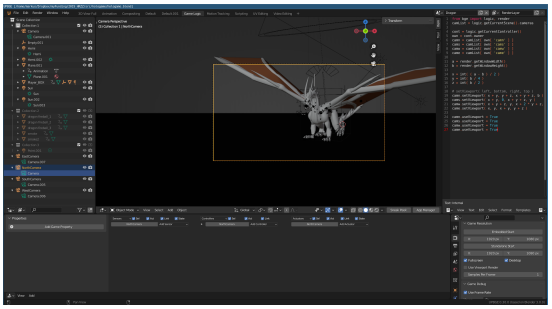

Figure 5: UPBGE interface

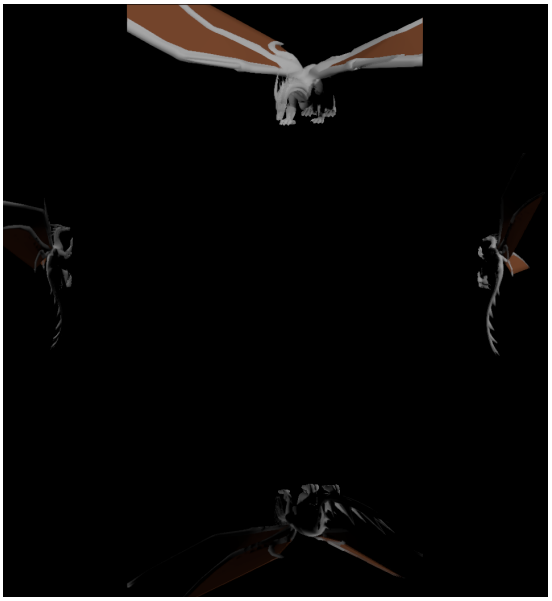

Figure 6: Display with four parallel cameras

5 Conclusion & Future Reasearch

In this paper we have provided a first step towards the implementation of a streamed 3D holographic game engine. We have developed a proof-of-concept game streaming platform that allows us to stream almost any game developed for the Linux X Window System to a web based VNC client. Additionally, we have extended the UPBGE game engine with a output transformation script that allows us to display games developed in the engine on a pyramidal holographic display device based on Pepper's Ghost technology.

Our future research is aimed towards enhancing this technology with possibly other 3D game engines that allow for multiple camera views that could be embedded into game cartridges as described above. Additionally, we are working on the design and assembly of a 3D holographic game console based on the technology described herein.

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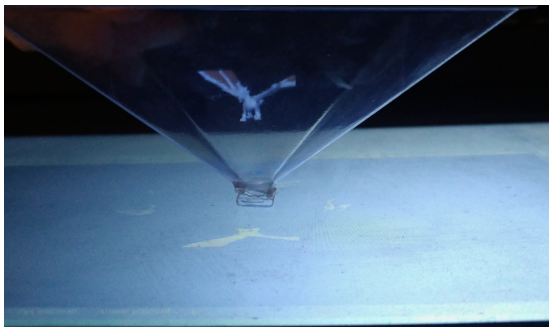

Figure 7: Hologram-like appearance

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