Designing Architecture for Constructing a Virtual Marine World

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Summary
To construct more realistic virtual marine world, it required the marine environment and the production of objects through consideration of spatial characteristics and a system that can support the various forms of interactions. This paper proposes an architecture that includes realistic data, smart object modeling, 3D visualization and interaction that are the levels of the construction of the realistic virtual marine world. The proposed architecture has the advantage of the articulate combination and extension of environment recognition part, event control part, and behavior control part and fish object modeling part. The proposed architecture can be applied to the production of the realistic virtual marine simulation, marine game and marine ecology training material contents.

Key words:
Virtual Reality, Virtual Marine World, Artificial Fish, VR Engine, Architecture.

1. Introduction

Virtual Reality(VR) is the virtual world created by the computer that produces the various techniques and the theoretical bases that are needed for the techniques that increases possibility of the natural interaction for the virtual reality as real reality through offering the users to access to it through various sensation channels [1,2,3]. This kind of Virtual Reality techniques are applied in various fields such as computer graphics, CAD, GIS, multi-media, games and more and recently the research of the virtual marine world for the virtual experience of the marine environment is in progress[1,2,3,4,5].

In the established research the considerations for the marine environment and the spatial characteristics was minor [4,5,10] as the research was inclined towards the artificial life habit and behavior it self's reality reproduction. Furthermore the research is staying in the marine data's scientific visualization according numerical value analysis which shows the limitation to express the overall virtual marine world [2,3,12].

In this research, to offer the more realistic impression to the users it has to define the element that has to be considered for the virtual marine world and propose the architecture that can support this. The proposed architecture support the realistic expression of the marine environment, support the VR Engine for the user's interactions and support the virtual environment element and the objects that differ by the situations' articulating interactions to construct more realistic virtual marine world. Furthermore there is the advantage of the possibility of the articulate combination and extension of the environment recognition part, event control part, and behavior control part and fish object modeling part. The construction of this paper is as followings.

In chapter two it is about the production of the virtual world technique's related works in chapter three it is about the considerations for a virtual marine world, in chapter four it is about a architecture for construction a virtual marine world, in chapter five it is about the implement and the analysis of the virtual marine world that applied the proposed architecture and lastly in chapter six it is about the conclusions and future work.

2. Related Works

Virtual marine world construct technique, which uses Virtual Reality technique, is simply beyond 3D space production technique dimension but put importance in the ocean-physic phenomenon, realistic data construct technique that is based on marine environment understanding and expressing articulate relationship technique development is important. [4,5]. Especially, expressing the marine ecology realistically means the use of the realistic information and image data to model the object to guarantee the visual reality and to present the animations of the object and the behavior to be similar to the real habit of the object is very strong[1,9,11].

In the established research of the 'Virtual Human[6,7,8]' and 'Artificial Fish[4,5]' through letting it imitate the really existing human and fish's intelligent behavior, it approaches the realistic virtual reality construct. Especially, the research of the 'Artificial Fish [3,5]' researching various marine ecology that consider the environment such as, anatomy, physics, biomechanics, oceanography, etc. However, from the overall point of view from the research the artificial life's behavior simulation are limited and due to the lack of the reality of

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viewpoint of the data there also is a limit in the construction of the virtual marine world. From the system design's point of view the movement presentation of the marine effectiveness and fish object, which depend on the various marine environment element, has to be diversity and for the various forms of the virtual marine world construct the structure and the function needs the scalability. For the new environmental element and the expansion of the fish types the research for the architecture that is possible to control through the articulately combined and expanded environmental recognition part, event control part, behavior control part and fish object modeling part. Through focusing on this chapter's mention of the problems and requirements, it draws the consideration of virtual marine world and designs the architecture by basing on the drawn consideration.

3. Considerations for a Virtual Marine World

To construct a virtual marine world and to design the architecture to support it, the following core techniques has to be considered and this can be divided by four. First is through the construction of the reality data, obtain source data production of technology for the virtual marine world construction. Second marine life modeling technology by using artificial life technique, third is 3D data visualization technology and lastly the interaction technology.

3.1 Contracting of Realistic Data

When constructing the virtual marine world, it needs the data that is based on reality to increase the realistic. Especially, to express the 3D geography and marine life more realistically the texture that will be fit on the mesh that composes the model is important. To obtain the realistic texture, the images and video data has to be obtained first and the method is as following [7].

1) Reconstruction from 2D Photos
2) Reconstruction from a video sequence
3) Construction based on the laser technology

Through using the obtained images and video data to map the 3D object, the real picture based photorealistic texture can be made certain through the process of Fig 1.

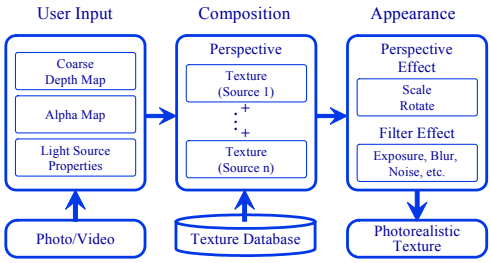

Fig. 1 Making Pipeline of Photorealistic Texture

3.2 Smart Object Modeling

The element of viewpoint to express the virtual marine world realistically is important but in addition the characteristics of the virtual environment's object, behavior of the agent and logical relationships has to be guaranteed to articulately combine several elements of the virtual environment to the real environment. [2,3,4,5,6]. This mean the possible event can be produced in the real marine environment and continue the sense of reality.

In this research, as mentioned before to show the marine environment logical object. Smart Object modeling [7,8] concept was applied to the Fish Object which presents the Smart Fish model.

3.3 3D Visualization

The important point of the 3D visualization is how fast the 3D mass storage data can be played. Especially, when constructing a virtual marine space the most important point is producing the quality that is close to reality by rendering real-time the mass storage of the 3D data and controlling effectively in the 3D space. This research support the various improvement of the 3D visualization by using DirectX[11,12,13] as the foundation and developing VR engine by specializing virtual marine world.

3.4 Interaction

A virtual marine world should support the interactions between virtual space and specific objects. The formation of the interactions is divided in four, user and the virtual space, user and the object, object and object, object and space. Every interaction become materialize through events and messages in this research, by 'Trigger System' and 'Behavior System' the various forms of interaction's implement is possible.

4. An architecture for constructing a Virtual Marine World

To support the construction of the virtual marine world, the designed architecture as mentioned in chapter three was designed through specific examination of the four technology consideration (Realistic Data, Smart Object Modeling, 3D Visualization, and Interaction). Due to the consideration of the reuse of software it was composed so each system interfaces are not dependent and to make the extension convenient. Fig 2 shows the composition of the proposed architecture.

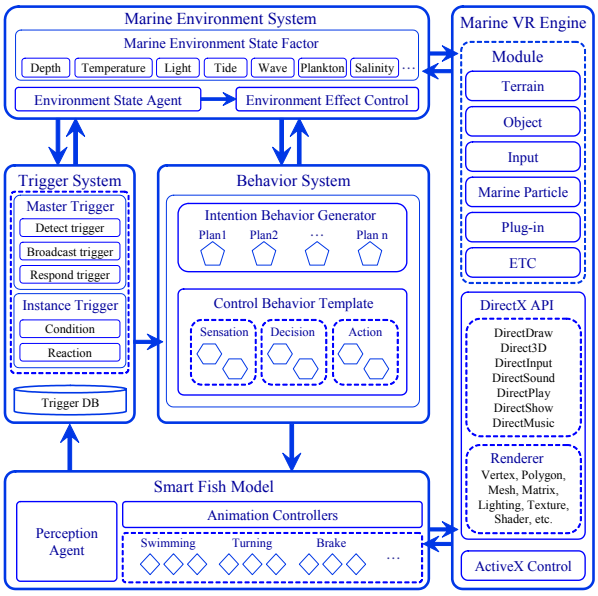

Fig. 2 Composition of Architecture

4.1 Marine Environment System

The marine environment endlessly change due to the various primary factors including the location and time, and this changes should be effectively apply to the marine effect and marine ecology[3,4,5,9]. The data that is used in Marine Environment system pursues the changes in the program and include the environmental numerical value, which is the property value. Property value includes light, temperature, tide, plankton and more and it expresses the marine space that depend on each numerical value by rendering through various graphic effect information 'Marine VR Engine' Each marine environment numerical data perform real-time monitoring by 'Environment State Agent' and handle the messages that are for the various interactions between 'Trigger System' and 'Behavior System'. Fig 3 is the structure of the 'Trigger System' that include the architecture, Table 1 shows the types, materialization and the important levels of the primary factors that effect the marine environment[9].

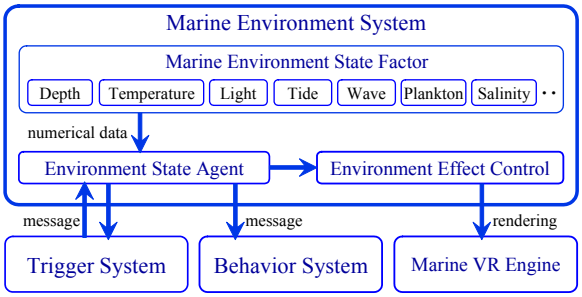

Fig. 3 Marine Environment System

Table 1: Factors of affecting Marine Environment

Classification	Elements	Important level
Physical Factors	Light	High
	Temperature	High
	Tide	High
	Wave	High
	Salinity	Middle
	Nutrients	High
	Dissolved gases	Low
	Depth	High
Biological Factors	Feeding relationships	High
	Crowing	High
	Metabolic wastes	Middle
	Defense of territory	Middle
Biogeochemical Factors	Carbon	Low
	Nitrogen	Low
	Phosphorus	Middle
ETC	Plankton	High

4.2 Trigger System

The general trigger system is possible to appoint the various events by using the condition-reaction paradise depending on the boundary area message, carry out and other movements. It also supports to compose the interaction environment easily for the object to explore[12,13]. Fig 4 is a structure of Trigger System that is included in the architecture. Trigger system is divided and designed into two big different types of triggers. First, as the 'Master Trigger' is in the charge of the virtual space boundary area, it deals with the interaction that occurs in the marine environment. This is depended with the function of detect, broadcast and respond. 'Instance Trigger' is in the charge of operating an event about an identification object as each object possesses a trigger. 'Trigger DB' includes each boundary area's extent information and object location information as well as other condition-reaction information.

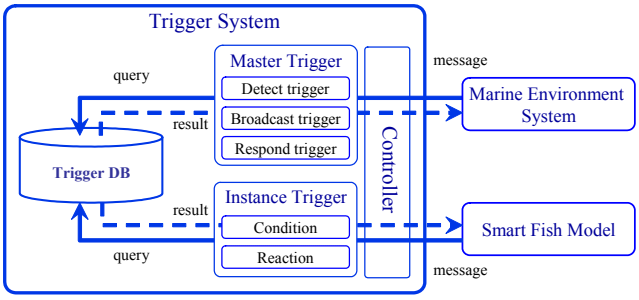

Fig. 4 Trigger System

4.3 Behavior System

To give the reality to the artificial life, the essential element is to create the control structure of movement's feature that resembles with the living creature[4,5,6,7,8]. Through 'Behavior System', which is included in the architecture, it carries out the basic behavior that the object planned by the use of the behavior base control structure. It is composed to cope flexibly in an exception situation as it occurs. Fig 5 shows the involvement of 'Behavior System' in the architecture.

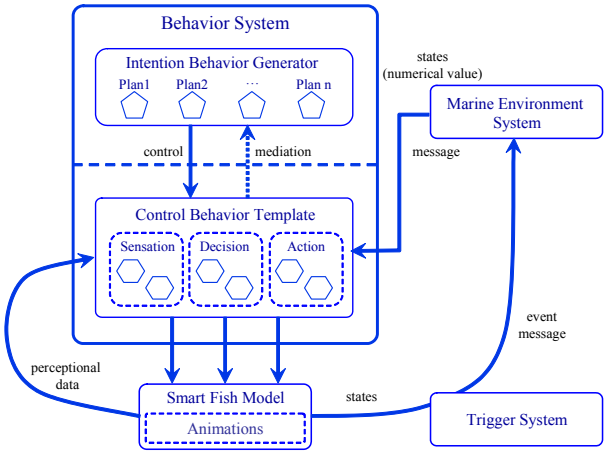

Fig. 5 Behavior System

Through 'Behavior System', dividing the behavior of behavior base control structure layer features are the following.

1) Intention Behavior: It is a controlled logical collection that is achievable for the identification purpose through the restrain water level behavior's control and control. A behavior of a plan level is checked continuously to whether it is achieving its purpose, modify the plan and if the sub behaviors are activated or deactivated.

2) Control Behavior: It is a collection of controlled reflect behaviors based on the information that is recognized from the outside. The control water level's behaviors concurrently act and only possibly choose the high ranking behavior to control as activates.

3) Animation Behavior: It exists as an independent behavior group each, and each behavior is organized into an animation that restrains the replay of key frame. Table 2 is an example of a behavior that is divided into depends on the restrain water level.

Table 2: Classification and Example of Behaviors

Classification	Example
Intention Behavior	Come up to user, mating, etc.
Control Behavior	Avoid-static-obstacle, Avoiding-Fish, Chasing-target, Eating-food, Mating(looping, circling, prey, ascending, nuzzling), Wandering, Escaping, Schooling, Leaving, etc.
Animation	Swimming, Turning, Braking, Moving Fin, Mouth, Gills, etc.

4.4 Smart Fish Model

To make the artificial life to have the same impression that is in the living creature, we need the reality animation technique and seeming intellectual behavior style control structure. Fig 6 is a 'Smart Fish Model' structure which was presented in the architecture.

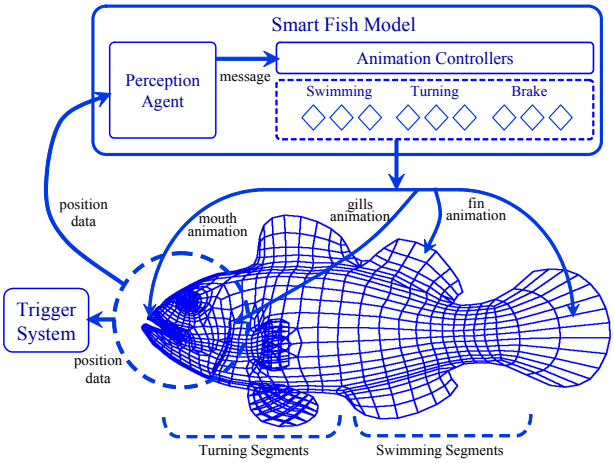

Fig. 6 Smart Fish Model

'Smart Fish Model' controls the behavior of a fish by using the key frame animation which was produced by the use of a realistic image of a fish. The key frame can be divided into a number of different behavior parts, such as mouth, gill and fin. These different types of key frames are compounded and are used in arranged rows. These movements are depended on the situation of 'Swimming', 'Turning', 'Braking' by 'Animation Controller' they compound and express the movement of a fish more realistically.

'Perception Agent' is the pursuit position of the fish in the virtual marine world, so it can send the information when the fish goes to the boundary area and when event between objects to 'Animation Controller'. Therefore it can express the suitable movements from the interaction environment.

4.5 Marine VR(Virtual Reality) Engine

The most important thing when constructing the virtual marine space is rendering the memory storage of 3D's computer data. Also producing the close to the reality's quality and controlling effectively in 3D. In this research, VR Engine was planned on the base of DirectX[11,12,13], produced of a high quality's graphic and added a extend of a function to have the same impression in the false image of 3D marine as in the reality. Especially, we added Web Plug-in that supports Web linkage, terrain, object, camera, sound and other basic 3D functions and particle for the marine special effect to organize the virtual marine environment. Table 3 is shows the division of an engine function.

Table 3: Function of Marine VR Engine

Class	Element	Explain
Terrain	Terrain	Create the geography height and control
	PathFinding	Finding the path by using A*[13] algorism
	Frustum	Optimize rendering by using Quad Tree algorism[13]
Object	Mesh	Loading 3D mesh through XFile[13] as well as controlling
	Texture	Dealing with the realistic texture image
	Animation	Manage the function of bone animation and skinned animation
	Billboard	The function of billboard
	2DInterface	2D Interface
	3DInterface	3D Interface
	LOD	Level of detail (XML file format)
Input	Mouse	Input of using a mouse
	Keyboard	Input of using a keyboard
Marine Particle	Lighting	Light diffusion and Daylight
	Color	Controlling the whole color of the marine
	Fog	The effect on the way fog
	Water wave	The effect of water surface at the Terrain
	Tide	The effect on the way water flow
Plug-in	WebPlug	Linkage on the web through ActiveX control
	Exporter	File(Binary), Script(File)
ETC	Camera	Use Direct3D camera
	Sound	Output by loading sound file

5. Simulation and Analysis

This paper's architecture constructed virtual marine environment by organizing the presentation of each system. The constructed virtual marine world perceives the environment of the object's movement and produced for the animation to be achievable through an interaction between two objects. The object of fish and virtual environment was made to look and feel more realistic by making pipeline of photorealistic texture. Also fixed light, water stream, a water drop, an alga, plankton, impression of a color and fog to make the diverse effect in the marine. The designed virtual marine world is simulated through the real-time graphic rendering process, which is through 'Marine VR Engine'. Fig 7 shows the creation of the space and a course of a fixed area that was for the acknowledge situation.

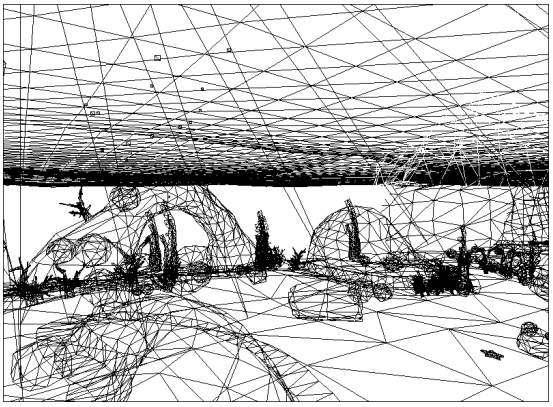

Fig. 7 Creation of the Space and a Setting Area

Fig 8 is the progress of the marine effect and applies the photorealistic texture to the geography and the parts that is followed by the marine environmental state information.

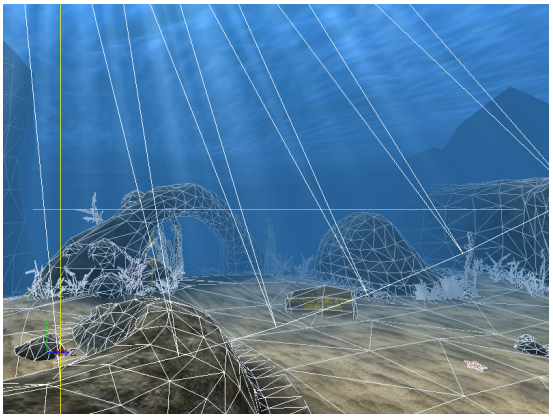

Fig. 8 Apply the Effect and the Texture

Fig 9 is the progress of the marine world's simulation through final VR rendering by placing the fish objects that are implemented in the shape of the 'Smart Fish Model'.

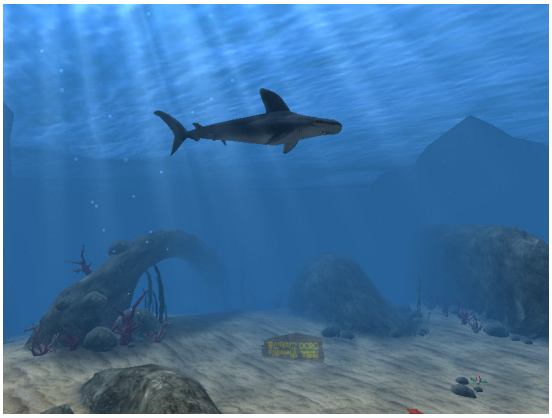

Fig. 9 The Smart Fish and Rendering

A research was continued in a form of architecture to construct the virtual marine world. There was a prove through simulation that it can be solved by the usage of each system, which is constructed by four considerations (Realistic Data, Smart Object Modeling, 3D Visualization, and Interaction). Table 4 shows the consideration of the construct of the virtual marine world.

Table 4: Evaluation Result

Item	Suggested Architecture
Realistic Resource Data	Pipeline of Photorealistic Texture
Smart Object	Smart Fish Model
3D Visualization	Marine VR Engine
Interaction	Trigger System, Behavior System

6. Conclusions and Future work

For the virtual marine world to look more realistic, it was constructed to have the same background and environment of the marine. Also it had to construct the same habit of the fish and similar expression. To do this, Realistic Data, Smart Object Modeling, 3D Visualization, Interaction were needed, and need to develop flexible architecture.

In this research, it presented the architecture for the construction of the virtual marine world. The suggested architecture supports 'Marine Environment System', 'Trigger System', 'Behavior System', 'Smart Fish Model', 'Marine VR Engine' to express the marine be more realistic. Also the effect of the marine and space through the linkage between the systems and it is possible to express ecology of the marine realistically. Especially, environment recognition, an event control, a movement control, and an advantage that the fish modeling can be combined and extended.

By using the suggested architecture, it can be used in the virtual marine simulation, marine game, the ocean ecology education and other more. Virtual world construct that use the 3D technology occupy a lot of computer resources. Therefore it requires technology to optimize the resource. The research that supports various user interfaces by the linkage of the 3D sound and the management of the sense of touch.

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