Development of Simulator with Cluster System for Towing Fisheries

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Abstract – Goal of this study is to implement 3-dimensional underwater appearance graphical display, fishery measured information display, sonar data representation and display, and 3-dimensional underwater appearance animation based on coefficient data of chaos behavior and fishing modeling of fishing gears from PC cluster system. In order to accomplish the goals of this study, it is essential to compose user interfacing and realistic description of image scenes in the towing-net fishery simulator, and techniques to describe sand cloud effects under water using particle systems are necessary. In this study, we implemented graphical representations and animations of the simulator by using OpenGL together with C routines.

Index Terms – Cluster System, Simulator, Visualization, Towing Fisheries

I. INTRODUCTION

To manage rational and highly efficient fishery, detecting target fishes and understanding the reactive movement of fishes for the shape of fishing gear under water should be made first. Simulations of numerical models[1] about the movement of fishes and the interception of nets, etc. are being implemented in various forms, however analyses including design factors, such as the movement of fishes for towing fishing gear and the size and shape of fishing gear based on that, are not being made. Also, the possibility of numerical modeling[2] and simulation techniques for the characteristic of towing movement about the shape of fishing gear[3], which is the most fundamental mechanism of fishing process, and the chaotic movement was found already a few years ago, however the high-speed processing ability of highly efficient computer for practical applications appropriate for field conditions is insufficient yet.

Due to recent development of information and communication and OS in the area of computer technology, the PC cluster technology[4][5], which uses one parallel processing computer connecting multiple general-purpose PCs only by communication, was developed and highly efficient and low-priced system comparable to supercomputer was developed. While the PC cluster system has the advantage that its price is low and its manufacture is easy, parallel processing program utilities[6] for high-speed processing are not many yet and programming works are complex. Accordingly, constituting and operating the cluster system, which is high technology computer hardware and software, applying it to the area of fishery information process, and in the end developing the simulator of towing fishery, it is necessary for fishery managers to employ it as an efficient means for towing instruction, improvement of fishing gear, prediction of fishing amount, etc.

The simulator of the study uses two monitors to display screen of underwater virtual reality during fishing process and screen of fish detection, fishing gear like net recorder and fishes measurement, and is composed of fish detection screen, operation state screen, such as fishing boat and fishing gear, and underwater fishing process screen. Also, to function as the simulator for instruction, the search of the selection of fishing ground and the condition of fishing ground, the detection of fish shoal, the change of shape by the change of fishing gear design, the change of towing condition, the analysis of the composition of fishes and the characteristic of fishing selection, etc. are selected by stages, and then graphic works and animation are made. In particular, it is designed to be implemented in the PC for Window as well as Linux server.

In Paragraph Two, implementation of the cluster system for highly efficient computing system is explained. In Paragraph Three, main modeling of the simulator is described, and in Paragraph Four, the simulator implemented actually is explained. Finally, in Paragraph Five, conclusions and applications are suggested.

II. CLUSTER SYSTEM

As for the implementation and development of system hardware, OS and control programs in the area of the development of the cluster computer system for the development of towing fishery simulator, the prototype system for core function was first developed, and software and hardware environments for the constitution of final system were implemented, and then the study of performance analysis and optimization of final system was performed. The cluster system finally developed was composed of hardware and system software constituted for highly efficient arithmetic processing, and is shown in Fig. 1.

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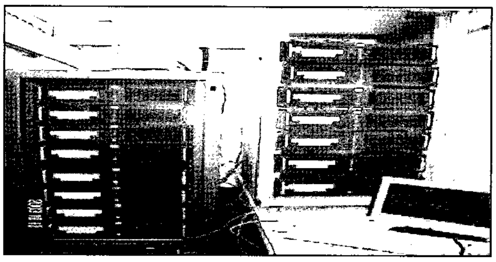

Fig. 1 Alpha cluster system

Hardware is an 100 Mbps Fast Ethernet and connected 1 master node, 16 operation nodes and 1 monitoring node. The master node was composed of 833 MHz alpha processor and 1 GBytes main memory unit, the operation nodes composed of 600 MHz alpha processor and 256 MBytes main memory unit, and the monitoring nodes composed of Intel 2.5 GHz CPU and 1 GBytes main memory unit. As for the system software, VIA (Virtual Interface Architecture) was transplanted to each node and to Linux 2.2.14 kernel for operation and communication, MAT (Monitoring and Administration Tool), PBS (Portable Batch System), etc. were installed for the management of cluster, and LCB (Light weight Corefile Browser) and Pablo on MPICH 1.2.3 version [7] were installed for the parallel performance of arithmetic operations and programming environments. For the performance analysis and optimization of the developed cluster system, the performance of the simulator and animator in the final system was analyzed and debugging for tuning and optimization was carried out.

To estimate the performance of kernel benchmark program and towing fishery simulator in the final system, the parallelism and performance improvement of each program were estimated through many experiment stages. First of all, from the floating point arithmetic performance test results of NAS[8] benchmark LU (Lower-Upper Diagonal Benchmark) program generally used, as shown in Fig. 2, the parallel arithmetic performance capacity was about 1.62 GFLOPS.

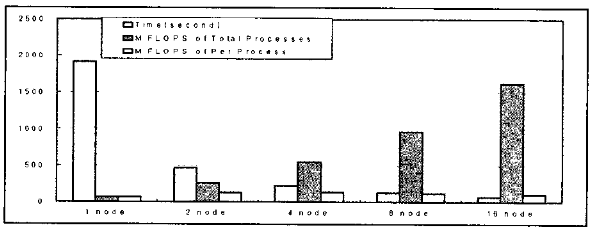

Fig. 2 NAS benchmark LU floating point arithmetic performance test results

The MPI function to process in parallel Fortran programming, in which the successive processing of the fishes movement model by chaos theory in towing fishing gear was made, in the cluster system was newly added. When the parallel program to obtain the π value of circumference by COMPAQ FORTRAN 90 was compiled and operated in 10 nodes by MPICH, to identify the performance of the cluster system implemented in the study, the parallel efficiency of the relative time required was approximately 83%.

III. TOWING FISHERY MODELING & SIMULATOR

A. Field operation data collection and analysis

As for the approximate constitution of the model for developing towing fishery simulator, bottom trawl, midwater trawl, boat trawl, boat anchovy tow net, etc. were made as the main target fishery, and fishing ground environment model, fishery creature model, fish detection model, fishing boat plying model, fishing gear shape model, movement stimulus model, chaos reaction model, fishing model, etc. by each fishery were made as the lower model. As the basic fishing data to constitute and verify the towing fishery model, operation locations, towing depth of water, towing time, fish kinds, fishing amount, etc. were collected and analysed for tow-boat trawls fishery (100-ton class 7 barrel, 1996-1998), north-sea walleye pollack trawl fisheries (5000-ton class, 1995-1997), and boat anchovy tow net fisheries (20-ton class 1 fleet, 1995-1996, 1999-2001). Since the yearly change of fishing amount was shown to be non-periodic, nonlinear, complex and chaotic, the actual change of fishing amount like this[9][10] will be used as the basic data to verify the resources detected in fishing simulation, the amount of fish shoal encountered and the fishing selection characteristic during fishing process.

B. Physical environment model of fishing ground

As for important factors as the physical environment of fishing ground, which is the object of towing fishery generally, such as water temperature, salt, seawater flow, water colour and transparency, observed data by sea area and by season were used. Next, in the seabed of fishing ground, the object of towing fishery, the unevenness, like reef zone, was seen to be not so excessive. Accordingly, random numbers were generated assuming that the dull unevenness and bottom materials, such as mud, sand and gravel, in seabed distributed randomly, and relative magnitude and occurrence location were made distributed with the accuracy between 0 and 1. The underwater optical model that has an main effect on the movement of fishes for towing fishing gear, supplementing existing study results[11], was computed measuring optical absorption coefficients directly in Korean waters, or collecting and arranging related investigated data. The brightness of light under water changes according to the absorption in air of the sunlight and the degree of incidence on the surface of the water.

Accordingly, to simulate and model the phenomena of nature more realistically in the study, the varied phenomena of nature were classified in various patterns that could be selected. Weather changes can be made by about 10 stages, from the case that there are few changes except the change of illumination by the change of the sun altitude in a short time, to the extreme situation that darkens below the 20% of normal illumination during about 10 minutes and brightens again.

The optical absorption under water largely depends on the Vertical Attenuation coefficient that influences underwater illumination and Beam Attenuation coefficient that influences visibility. Jerlov (1976) classified the degree of vertical attenuation of the sea throughout the world by the 5 stages of coastal region and by the 5 stages of oceanic region, and the Vertical Attenuation coefficient obtained from the data of Jerlov was about 0.12-0.78 for coastal regions and about 0.05-0.12 for oceanic regions. Since the Vertical Attenuation coefficient at the southern east coast of Korea is about 0.2-1.0, which shows a wide range of the coefficient, coefficients in the presented model are specified arbitrarily or selected according to the table.

C. Fishes occurrence model

As for the selection of fish kinds caught in towing fishery simulation, the top 5 fish kinds having the highest fishing rate for recent 5 years from 1997 to 2001 were examined according to not only large trawl, Danish seine and tow-boat trawls, which can be considered as business types of the coastal main towing fishery, but also business types of north-sea trawl, Pacific trawl, Atlantic trawl and Indian Ocean trawl, etc. of deep-sea fishery. The length and weight by fish kinds caught by actual fishing gear are data very necessary for the management and estimation of resources, but existing data were referred to in the presented simulation[12]. As for the size of fishes caught in the towing fishery model, the size of length by the total number of tails encountered by fishing gear at towing can be generated using several statistical random distribution. Generating random numbers was made using the subroutine of Press et al. (1996).

D. Fishing boat plying model

In the fishing boat plying modeling, which is the stage prior to operation, the process of detecting fish shoal, sailing in search of a fish shoal, was modeled. As for towing fishing boat, fishing boat size (tonnage), period output (horsepower), main operation areas, main fish kinds, etc. are selected for bottom trawl, midwater trawl, tow-boat trawls, boat anchovy tow net, etc. Year, month, day, hour, minute for the detection of fish shoal as the stage prior to operation are selected, and starting location (latitude degree, minute, longitude degree minute), ship speed (knot), ship's course (360 degrees) of virtual plying waters are input. Ship speed and ship's course can be changed even during plying. In the study, possible plying waters around Korea were made the Korean Peninsula waters from 30 degrees north latitude and 120 degrees of east longitude to the north in the East China sea, from 42 degrees latitude and 120 degrees longitude to the east in the west sea, from 30 degrees latitude and 133 degrees longitude to the north in the southern sea, and to 42 degrees latitude and 133 degrees longitude of the East Sea

The sea situation (National Fisheries Research and Development Institute, 1998-2002) and the weather (Korea Meteorological Administration, 1998-2002), etc. of the target fishing ground were compiled as a database using the existing data, and water depth, water temperature, salt, flow direction, flow velocity, transparency, underwater illumination, cloud amount, eave height, wind velocity, etc. by time and location were obtained by interpolating linearly by water depth or location and displayed. When casting fishing gear in desired time and location during fish detection and starting operation, these informations are used as factors necessary for the fishing process model of towing. In case that the operation zone is not in the Korean waters, factors about the above sea situation, the weather, etc. should be input directly. When the plying for fish detection begins, the information about plying, such as the sea situation and the weather, and the information about fish detection are simulated every 1 seconds and displayed by two screens. As the information about plying, engine RPM, pitch, latitude, longitude, ship speed, ship's course, flow direction, flow velocity, wind direction, wind velocity, etc. were made displayed applying the plying information monitor (TOIMEC INC, BRIDGE MONITOR BM-2000) of the Saebadaho (Gyeongsang National University, test ship 1000-ton class).

IV. GRAPHIC AND ANIMATION

As a graphic programming instrument that can satisfy the modeling of the previous Paragraphs, there is the OpenGL[13] with the most general and powerful API function. The OpenGL is a standard graphic API that is in common use basically in most system environments commonly used, and it is easy to recognize as a 3-D graphic and modeling library and high-speed. Also, it has efficiency of computation for graphic processing as well as excellent capability in displaying results. Since the OpenGL can be used by most host languages and commonly applied to Linux and Window environments, it will have a great advantage in the area to achieve educational and commercial purposes.

A. Image processing of seabed environment

The seabed environment is implemented using seabed Map, and is formed by multiple collection of single Map selected randomly by time flow and environmental change. Various objects in the seabed, such as stone, seaweeds and creature, are also formed by random searches. The seabed image is divided into three parts, that is, seabed, background underwater and objects in seabed. The image of seabed generates topography using texture[14], but simple texture makes topography flat and has limitations in realistic display. In the study, topographies close to actuality are generated by lifting up or taking down middle and coner points divided into many rectangles using fractal algorithm. This work is continued until all the elements in a topography array are divided. Since generating the coordinates of texture one by one gives an impression fixed by a constant topography, coordinates are generated using a random algorithm that generates each element points automatically using limited space coordinates as inputs. The image processing of background underwater zone was implemented by the effect of moving according to time flow using simple texture. Finally, underwater objects are similar to an algorithm that generates topography, objects are generated randomly when coordinate values obtained from the generation of topography are below the absolute value compared with specific height.

The Sand Cloud by otter board, etc. was implemented by the particle system[15] that was formed by multiple collected particles. If the generation of each particle is made by its individual computation, the time to display the swimming of overall fishes and the shape of fishing gear is considerably delayed. Hence, the process to generate Sand Cloud was simplified as possible and so implemented. However, it was made possible to represent realistic image using particle swimming algorithm without any problems so that visual characteristic similar to actual mud water may be shown. This is to have a little effect on the animation of fish movement, as a chief aim, and the graphic display of fishing gear as possible.

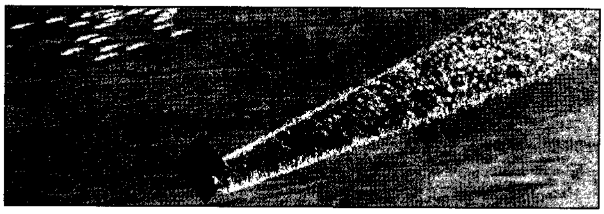

Fig. 3 Seabed Sand Cloud display

First, 16 multilateral particles were constituted and the effect of Sand Cloud was implemented by changing a unit image according to time flow for the particles. The image of mud water, which was made by actual graphic processing through the process, is shown in Fig. 3.

B. Fish detection image display and plying monitor

The signal processing of fish detection in case of cruising in search of a fish shoal on towing fishing boat is displayed by monitor images, according to the fishes distribution occurrence model and the fish detection model, based on Simrad ES60 color fish detection model. The fish detection screen in real time using the basic informations, such as year, month, day, hour, minute, the starting location of fish detection and plying, which are necessary for these models, is displayed, and the results are shown in Fig. 4. The signal processing of fish detection in real time is implemented after users input various informations; such as date, latitude, longitude, ship speed and ship's course, and the menu on the right side of Fig. 4 is the interface area of users.

To obtain the informations about plying, plying information monitor (TOIMEC INC, BRIDGE MONITOR BM-2000) was employed, and informations related to cruise and plying, which are transmitted from the fish

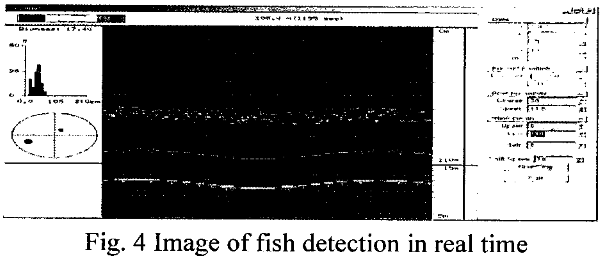

Fig. 4 Image of fish detection in real time

shoal occurrence model and the fish detection model, such as engine RPM and pitch, latitude, longitude, ship speed, ship's course, flow direction, flow velocity, water temperature, salt concentration, wind direction and wind velocity, were made displayed in real time.

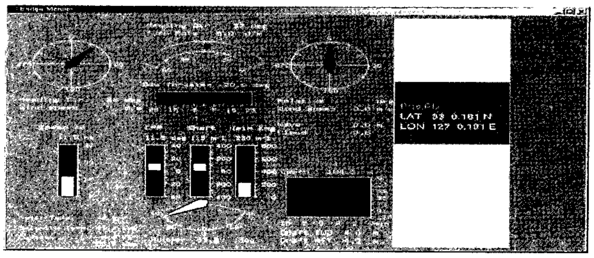

Fig. 5 Bridge monitor display

Displaying the situation that a fish shoal is caught by fishing net was implemented employing the new fishing net monitor, Trawl Eye (Simrad, TE40), which substituted existing net recorder, with the same algorithm as the above information screen processing of fish detection, as shown in Fig. 6.

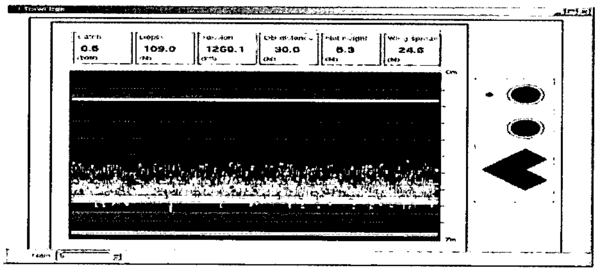

Fig. 6 Fishing net monitor Trawl Eye display

The water depth in the upper and lower parts around net height and the horizontal moving velocity of screen can be controlled using the right button, and the Gain control was implemented in the lower part of screen. In addition, otter board intervals, net height, wing intervals, warp tension, etc. about the unfolding of fishing gear, etc., which was the measurement information of fishing gear, were displayed in real time from the data of fishing gear shapes.

C. Three dimensional underwater shape graphic of fishing gear

In the study, applying 3 dimensional location information of each node forming fishing gear from the file of simulation results of the shapes of towing fishing gear, the function, which can draw the shape of fishing gear, first based on location information, was implemented by OpenGL, the proper function, such as movement, location change, size change, view change and rotation, were implemented using C routines. Also, additional interface, in which users can control fishing gear directly, was set. After loading the 3 dimensional node coordinate of fishing gear in constant array first, each node can be connected using the node connection information of fishing gear. At this time, nodes have only the information corresponding to half of actual fishing gear, because the shape of fishing gear is symmetrical and can be displayed with the coordinate information on only one side. The shape of fishing gear, in which mesh forms formed using the method are displayed, is shown in Fig. 7.

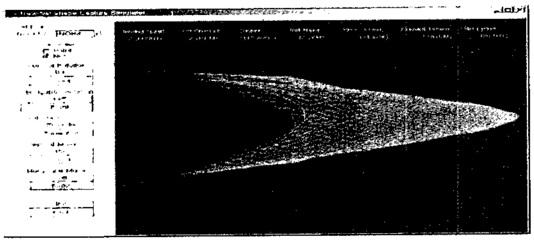

Fig. 7 3D underwater shape of fishing gear

And representing only node coordinates of the information of fishing gear by points, additional function that can check the display state of the nodes before the legs of mesh are connected is possible. The menus on the left side in the display of the shape of fishing gear are the interface tools for users. They include the kinds of each fishing gear, the rotation angle of each axis, the moving distance of axis, the functions of enlargement and reduction of the shape of fishing gear, etc. The rotation angle of axis can be specified from the left side of fishing gear to 90 degrees forward and from the left side to 90 degrees upward, to the zenith of net, respectively, and the enlargement rate can be appointed up to maximum 300%, and the reduction rate up to 50%. And the function that can see the only node coordinates can be selected in Set View panel.

D. Display of fish forms and swimming

Forms of fish kinds mainly caught in 4 main towing fishery were constituted so that swimming figures were displayed dividing an actual image from the still image of fishes into constant compartments. Each fish was designed to move by the swimming coordinate, and at this time the effect of swimming was added by the movement of each fin. In particular, the movement of tail fin changes right and left according to the x-axis coordinate. However, since the movement was ineffective for infinitesimal movements and rather resulted in complex texture process slowing the rate of display due to graphic computing, it was implemented by simple random changes.

E. Animation of fishing process

Based on 3 dimensional moving coordinates of fishes by time zone, which were transmitted from the simulation results of fish movement and fishing model, and fishery measurement informations, fish movements under water were implemented in real time in 3 dimensional. As for fishery measurement information, the informations, such as real time data and 3 dimensional coordinates of fish movement in real time, were applied.

Applying the real time data of 3 dimensional moving coordinates of fish swimming, the underwater movement phenomena of fishes were implemented by 3 dimensional animation. Data at 0.5 seconds intervals generated from cluster system were transmitted to client environment by constant time, and the number of fish is the proper number of each individual of fishes encountered with fishing gear in the fish occurrence model, and by this number each fish can be discriminated by step units. The coordinate values of each axis are generated identical to the display of the shape of fishing gear, and they are the coordinates generated centering around the origin marked in the shape of fishing gear. As an example of actual images generated from the method, the animation of fish swimming movements for tow-boat trawls is shown in Fig. 8, and it was shown similar to the observed results of field video[16].

Fig. 8 Animation of fish swimming movements for tow-boat trawls

Fishes move according to the coordinates of fish for each time step. As an example of simulation results, the animation results of reaction movement of yellow croaker for tow-boat trawls are shown in Fig. 9, by time zone elapsed after fishes were first encountered with fishing gear.

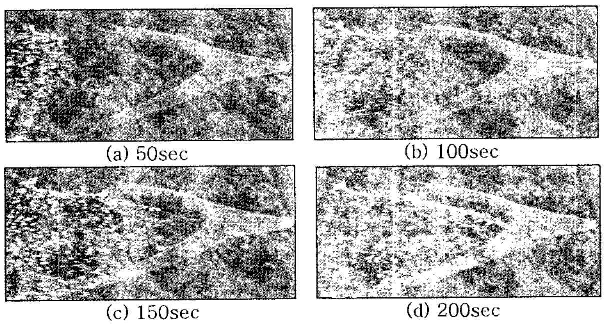

Fig. 9 Example of animation of fish movements for tow-boat trawls

V. CONCLUSION

In case of industrializing the results of the study diverse systems can be constituted and supplied according to user's request by kinds of fishery (bottom trawl, midwater trawl, boat trawl and boat anchovy tow net), hardware (the number of cluster nodes, and communication equipments), and kinds of developed software (the shape of fishing gear, the movement model by fish kind and graphic animation). Accordingly, the system can input fishing operation conditions for fishing gear selected by industry, perform the simulation of fish movement for fishing process, and display the computed results, and the computing time per one operation can differ according to hardware constitution. In single-line companies related to fishery or National Federation of Fisheries Cooperatives, it can be supplied to be used for instruction of fishing performance analysis, fishing vessel and fishing operation controls, fishing vessel technician or fishing technician. Also, since the alpha cluster system implemented in the study has excellent capability for engineering computing, it can be used for system rentals, the emulation of simulation for the towing fishery model, results sending, etc. It can be used for general purpose, for information processing and numerical computing, numerical modeling, etc. in the area of fisheries and ocean, which need quasi-supper computers. Finally, the bear wolf cluster system can be employed for the modeling of other fishery, such as simulator development of Purse Seine Fisheries.

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