Custom Shader and 3D Rendering for computationally efficient Sonar Simulation

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ABSTRACT

This paper introduces a novel method for simulating underwater sonar sensors by vertex and fragment processing. The virtual scenario used is composed of the integration between the Gazebo simulator and the Robot Construction Kit (ROCK) framework. A 3-channel matrix with depth and intensity buffers and angular distortion values is extracted from OpenSceneGraph 3D scene frames by shader rendering, and subsequently fused and processed to generate the synthetic sonar data. To export and display simulation resources, this approach was written in C++ as ROCK packages. The method is evaluated on two use cases: the virtual acoustic images from a mechanical scanning sonar and forward-looking sonar simulations.

SONAR SIMULATION APPROACH

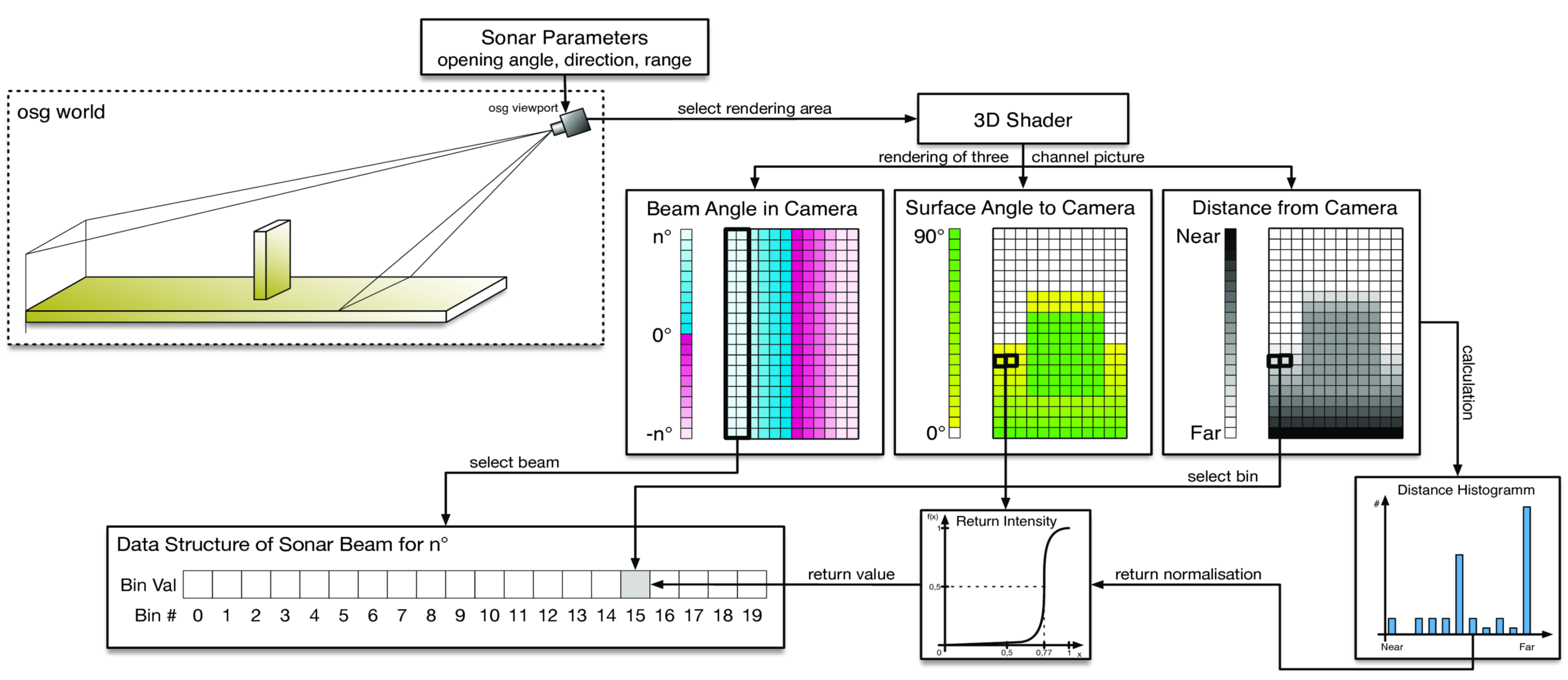

Figure 1 – Graphical representation of individual steps of sonar simulation

A. Underwater Scene

The ROCK-Gazebo [1] provides the underwater virtual scenario: Gazebo is responsible by kinematics; the visualization and ocean's visual effects are handled by OpenSceneGraph and osgOcean; and ROCK handles the communication between scene components.

B. Shader Rendering

It was specialized to simulate the sonar sensor as a camera of 3D rendering process, with same position, orientation and field of view. Then the 3D sonar matrix is computed as:

- **Intensity** simulates the echo reflection energy based on an object's surface normal;
- **Depth** is the euclidean distance between the camera focal point and the object's surface point;
- **Angle distortion** is the angular difference between the camera center column to its boundary column, for both directions.

C. Synthetic Sonar Data

- Split the matrix in beam parts. The shader is not radially spaced equally over the FOV-X degree sector, so each column is correlated with its respective beam, according to sonar bearings;
- Each beam sub-image is converted into bin intensities using depth and intensity values. A depth histogram is evaluated to associate each pixel with its respective bin;
- Due to acoustic attenuation in the water, the accumulated bins intensities are calculated by an energy normalization that applies a time varying gain to spreading losses in the bins.
- Since the shader data is in 8-bits space, if the number of bins are greater than 256, the final sonar image will present "black holes". A simple linear interpolation is done to distribute the sonar intensity data over bins.

D. ROCK's Sonar Structure

To export and display sonar image, the synthetic data is embedded as ROCK's sonar datatype and provided as a communication output port.

ACKNOWLEDGMENTS

RESULTS

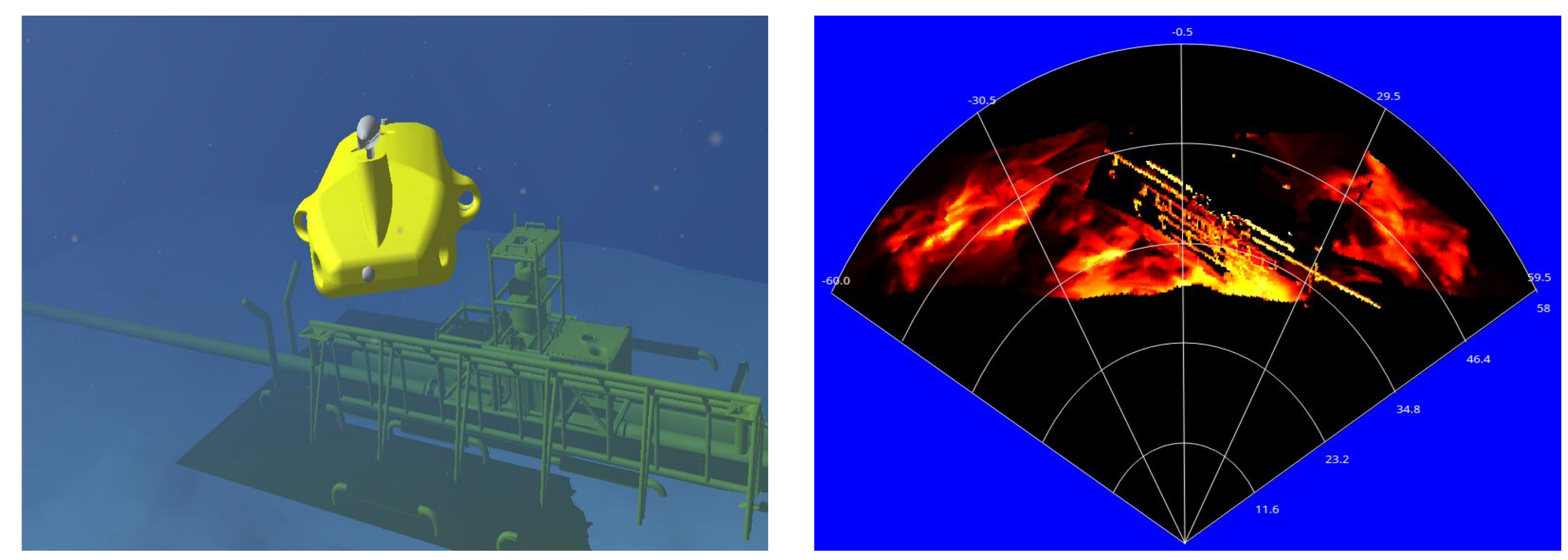

Figure 2 – The virtual manifold in the seabed (left) and its forward-looking sonar image (right). Sonar Parameters: field of view of 120º by 20º; 256 beams simultaneously; 500 bins per each beam; range set at 50*m*; and angle tilt between sonar and AUV at 20º.

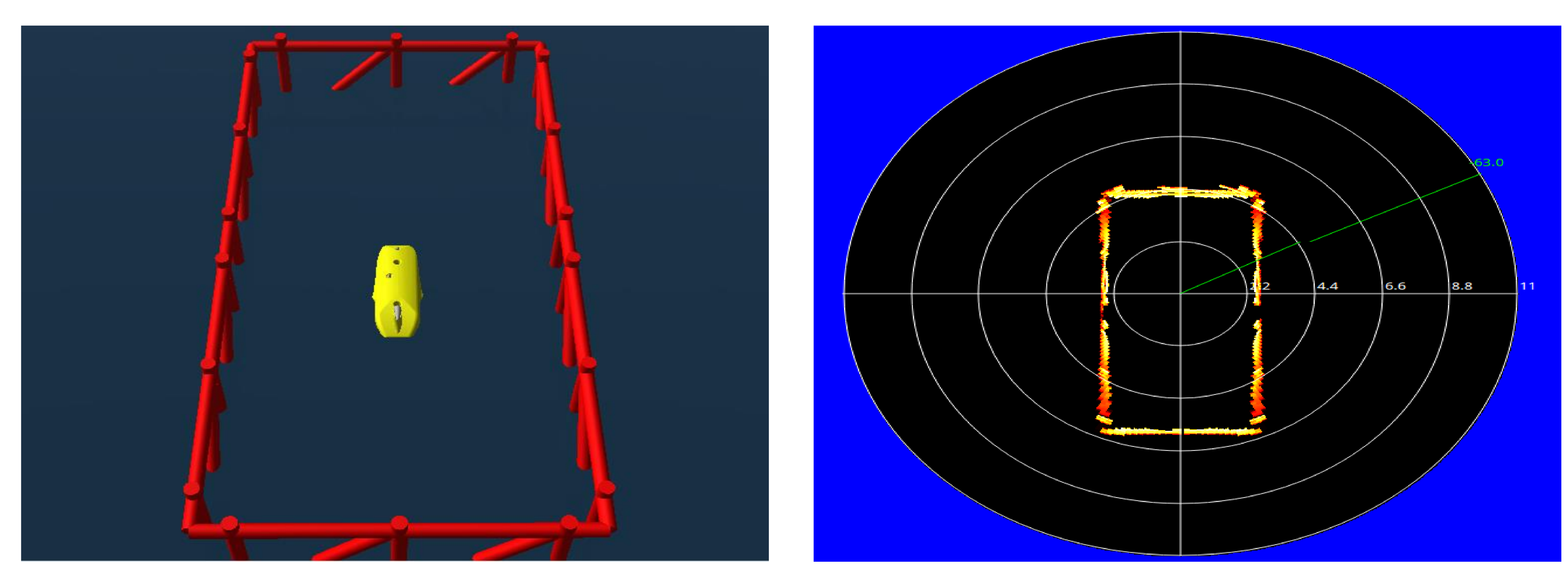

Figure 3 – The virtual grid surrounding the FlatFish AUV [2] (left) and its respective mechanical scanning sonar image (right). Sonar Parameters: field of view of 3º by 35º; 500 bins in the single beam; 360º sector scan reading; and a motor step angle of 1.8º.

Benefits of proposed method:

- It is able to simulate different kind of underwater sonars;
- With GPU rendering, it allows to produce qualitative acoustic images with a low computational cost;
- The efficient computational-time grants its usage in real time applications. For 150 sampling frames, one multibeam data is produced every 121.44*ms* and singlebeam data every 8.5*ms*, much faster than listed by authors in [3] (1*s*) and [4] (2.5*min*).

CONCLUSION & OUTLOOK

We presented a method using the shader engine of modern graphic cards to simulate different sonars in a time efficient-way. This system is already used with success in our underwater projects.
Future work will focus mainly on:

- Add different kinds of noise to make a more realistic sensing;
- Add a simple refraction model;
- Extend the 3D world by material properties to allow different sonar reflections.

REFERENCES

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