GPU-BASED 3D EIGENRAY SEARCH FOR UNDERWATER ACOUSTIC PREDICTIONS

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ISR LISBOA / UAlg / LARSyS

Abstract

Eigenrays can be defined as particular rays that for a given waveguide geometry connect the source to the receiver. The accurate calculation of eigenrays is a problem of great interest in underwater acoustics because they can be used for faithful predictions of the received signal. Furthermore, calculations of 3D eigenrays is a computationally demanding task, that requires the search to take place on the 2D plane of elevation and azimuth. To address this problem a Simplex based 3D search method [1] was designed in order to calculate efficiently and accurately 3D eigenrays; the method was found to provide accurate estimates of travel times and amplitudes, which are fundamental to predict the channel impulse response. Moreover, the inherent parallelism of the ray tracing algorithm and the high workload due 3D computation drove the development of a parallel GPU-Based version that achieved a speedup over 35x for numerical predictions.

TRACEO3D Gaussian Beam Model

The Simplex based eigenray search was implemented in the TRACEO3D Gaussian beam model which is a 3D extension of the TRACEO model developed at SiPLAB, University of Algarve.

Validation

The accuracy and efficiency of the Simplex based eigenray search in three-dimensions was intensively tested with comparisons against an equivalent 2D waveguide and against results from a tank scale experiment [2].

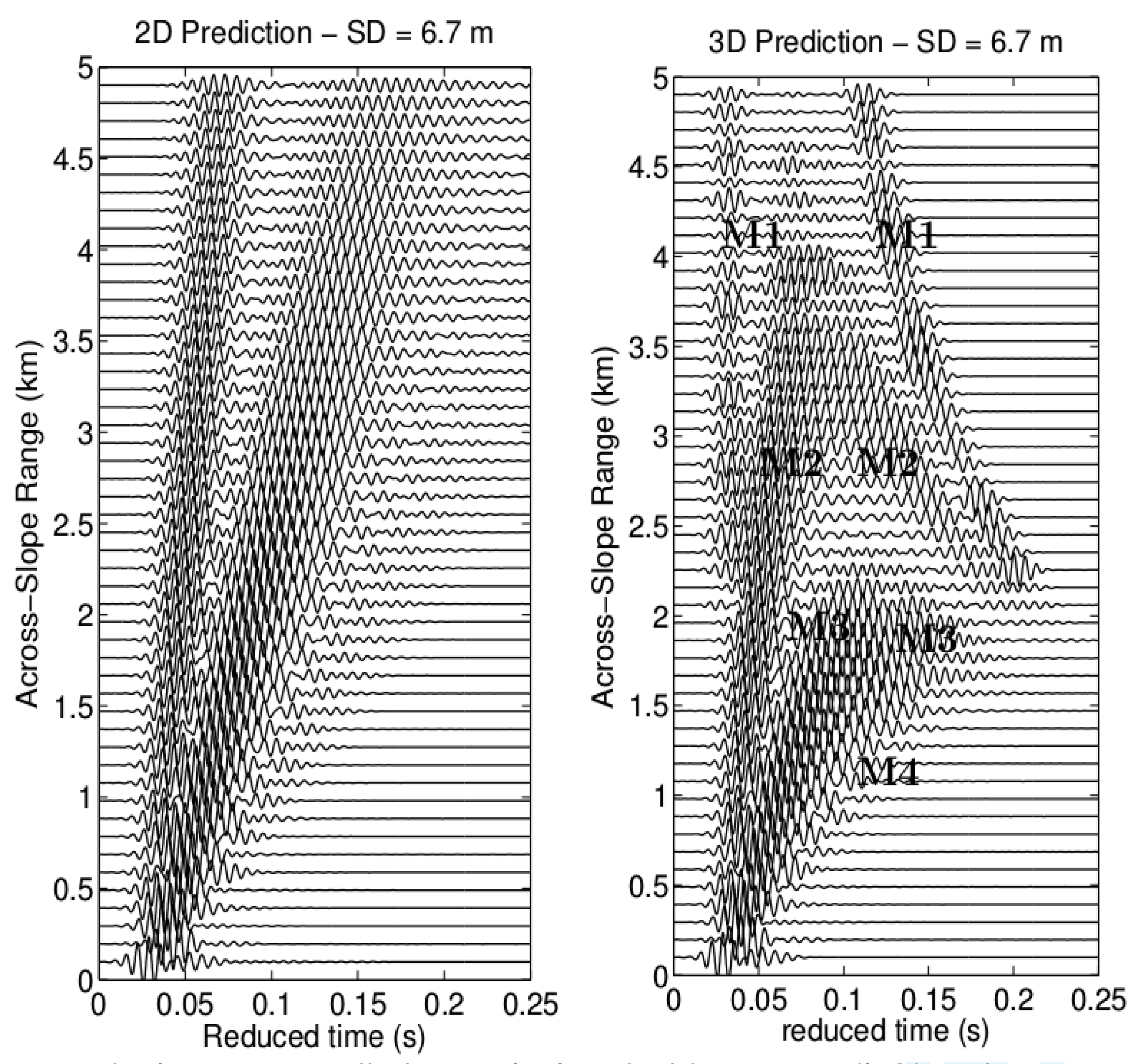

FIG. 1. Arrival pattern predictions calculated with TRACEO (left) and TRACEO3D (right) for the tank geometry from [1]. Four modes can be identified regarding 3D prediction.

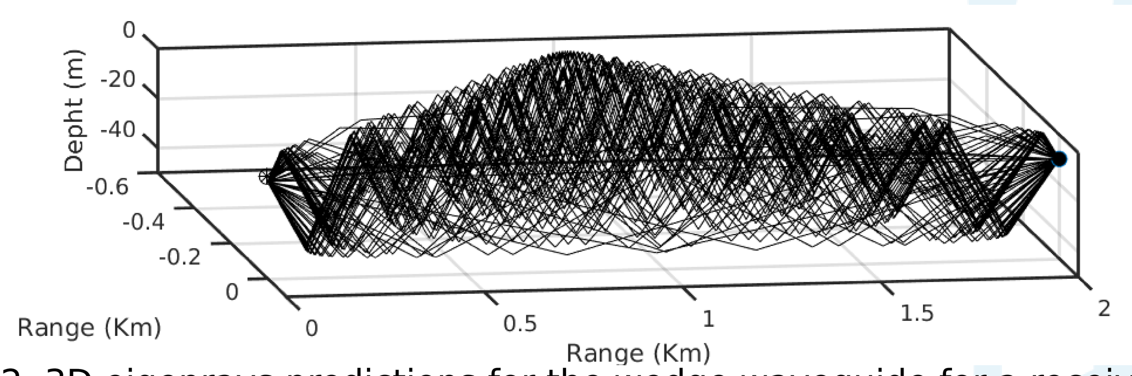

FIG. 2. 3D eigenrays predictions for the wedge waveguide for a receiver at 2 km.

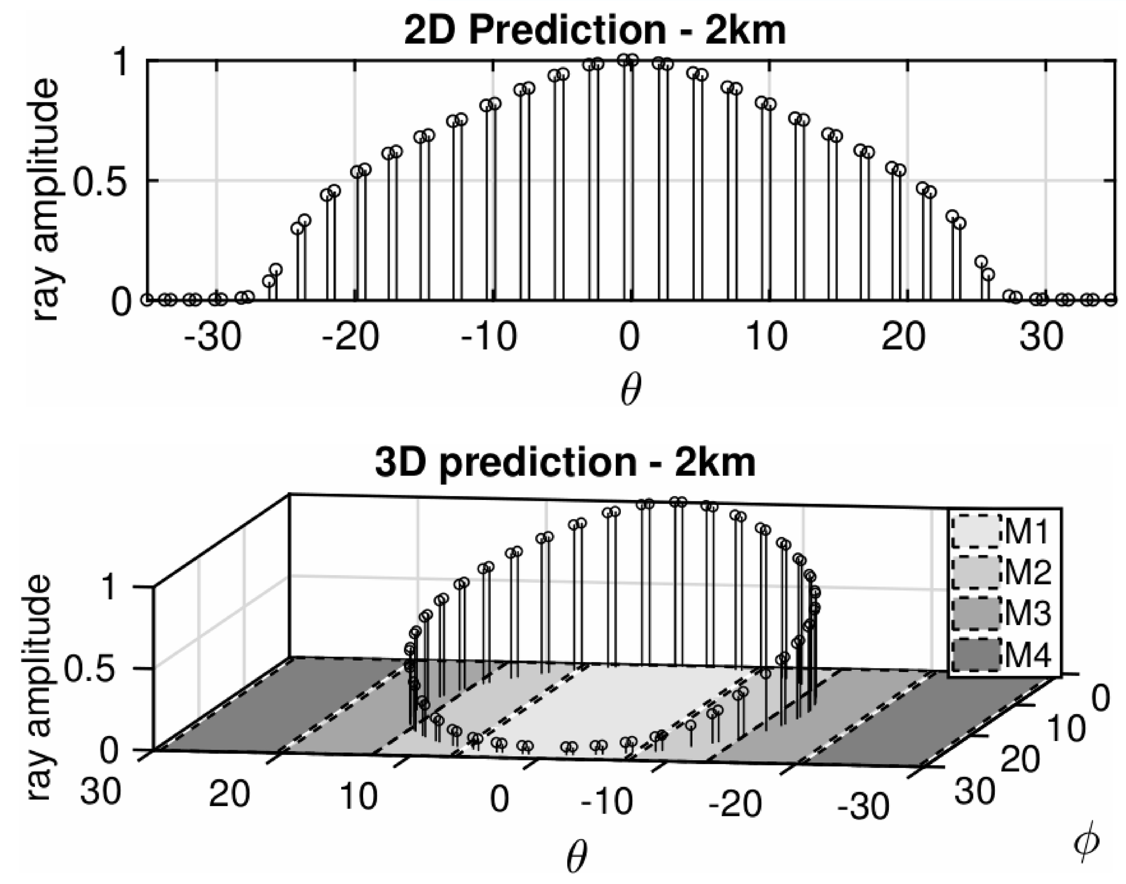

FIG. 3. Predictions of normalized amplitudes versus launching angles for a receiver at 2km: TRACEO (top); TRACEO3D (bottom) from [1]. The corresponding regions where modes can exist are indicated over the (θ,Φ) plane. The dashed lines stand roughly for the critical launching angle.

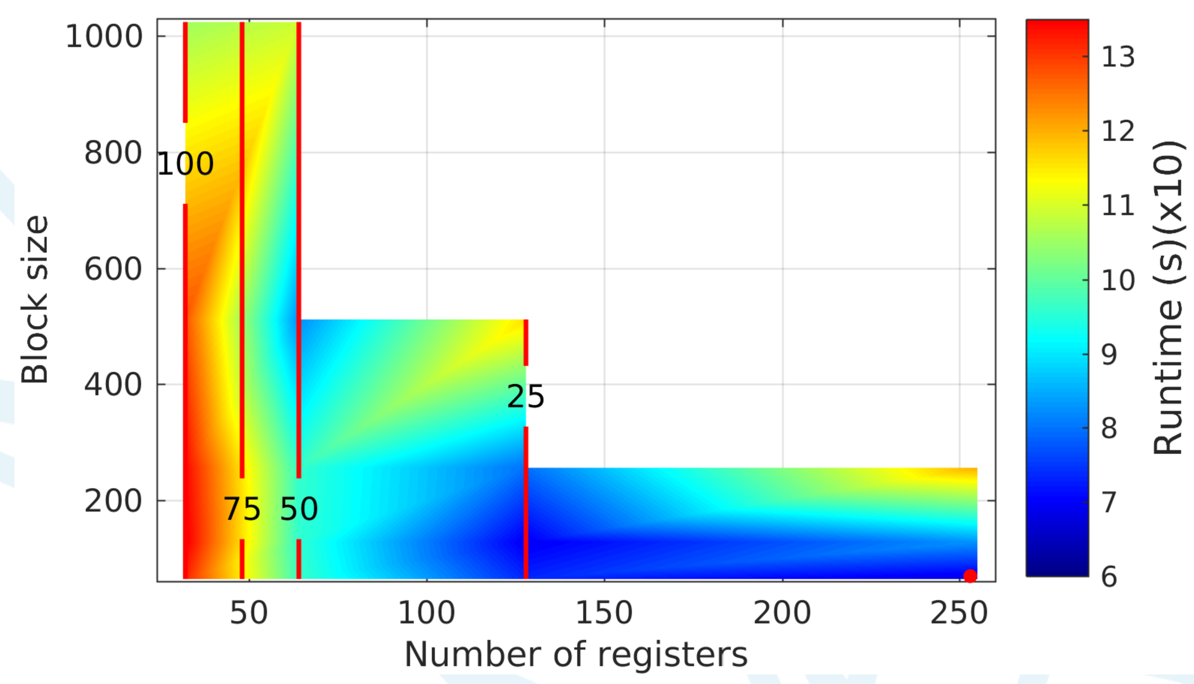

FIG. 4. Execution configuration results for different block sizes *p* and number of registers per thread. Vertical lines stands for the occupancy rate (%). The best option (red dot) corresponds to *p* = 64 with 255 registers per thread. Areas with no data represent parameter combinations in which the device (GeForce GTX 1070) does not have enough resources.

Conclusions / Future work

The proposed method allows an efficient and accurate calculation of 3D eigenrays by determining values of the corresponding take-off angles. The 3D predictions exhibited a remarkable similarity with most experimental features, replicating mode shadow zones, intra-mode interference, and mode arrivals. The parallel GPU implementation achieved a remarkable speedup of 35x, reducing the runtime for the predictions from 38,1 min to 1,07 min. Future work will be oriented to the calculation of eigenrays in typical ocean environments, with complex bathymetries or complex sound speed fields. The parallel code will be further improved to take advantage of hardware-based GPU filtering.

Aknowledgments:

This work received supported from the doctoral scholarship of CNPq (Brazil) and Brazilian Navy. Thanks are due to the SiPLAB research team, University of Algarve and to FCT project [UID/EEA/50009/2013].

References:

[1] R. Calazan and O. Rodríguez (2018), “Simplex based 3D eigenray search for underwater predictions”, J. Acoust. Soc. Am., 143(4), 2059–2065.

[2] F. Sturm and A. Korakas (2013), “Comparisons of laboratory scale measurements of three-dimensional acoustic propagation with solutions by a parabolic equation model”, J. Acoust. Soc. Am.,133(1),108–118.