3TU.AMI Applied Mathematics Institute

Ship Simulator

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Contents

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TU Delft: Elwin van ‘t Wout, Martijn de Jong, Martin van Gijzen

Marin: Auke Ditzel, Anneke Sicherer, Auke van der Ploeg

Rough seas

Problem: realistic simulator

- Required area 5 km x 5 km
- New screen every 0.05 seconds
- Bound on the CPU time

How not to do it

- Navier-Stokes equations
- Multi-phase flow
- Moving boundary problem

Boussinesq approach for water waves

(Gert Klopman, UT)

- Approximation valid for weakly non-linear and fairly long waves
- Takes into account the vertical structure of the horizontal and vertical flow velocity
- Much cheaper in CPU time

Pressure system

- Ax = b
- Large linear system of equations (ten million unknowns)
- Schilders/Koren, TUe
- Vuik/Oosterlee, TUD
- Veldman/Van der Ploeg, UG

How not to do it

- Compute the inverse of A
- Work increases quadratically

Tianhe-2 Supercomputer

3 million parallel processors
20 MW energy consumption
40 petaflops (40 x 10^{15})
390 million USD

How to do it

- Iterative solver (multigrid)
- Linearly increasing

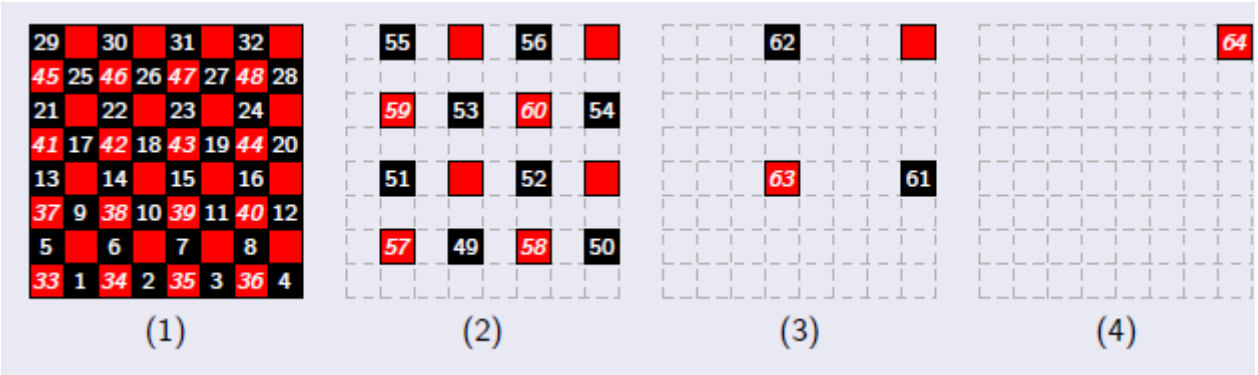
NVIDIA GeForce GTX 680 (Kepler)

1000 parallel processors
100 W energy consumption
1 teraflop (10^{12})
200 USD

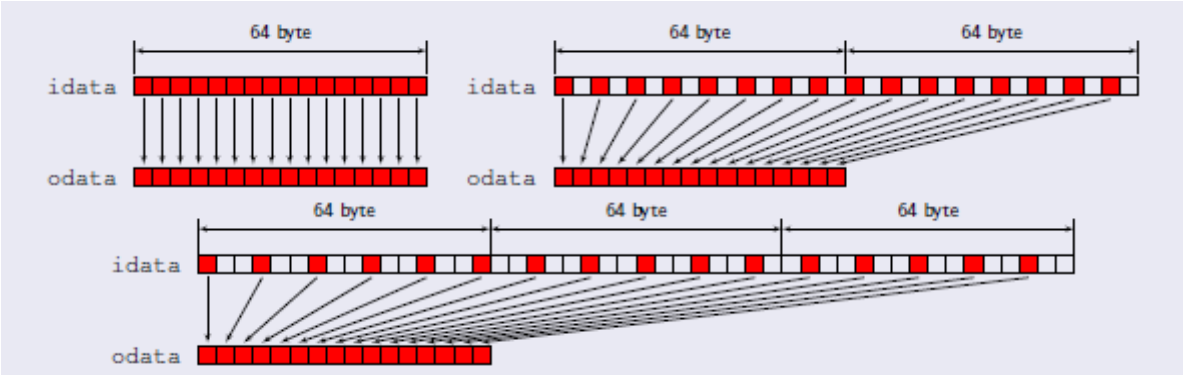
MSc Thesis of Martijn de Jong

RRB numbering

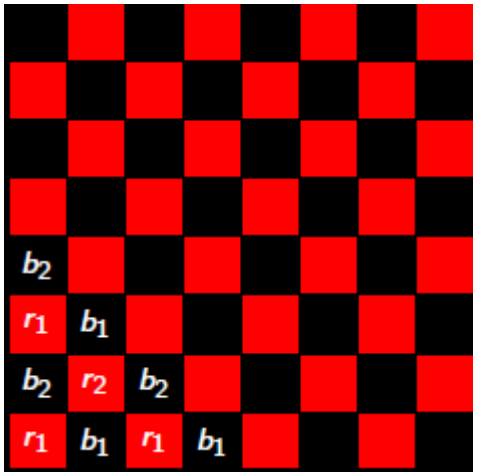
Example: 8 x 8 grid points



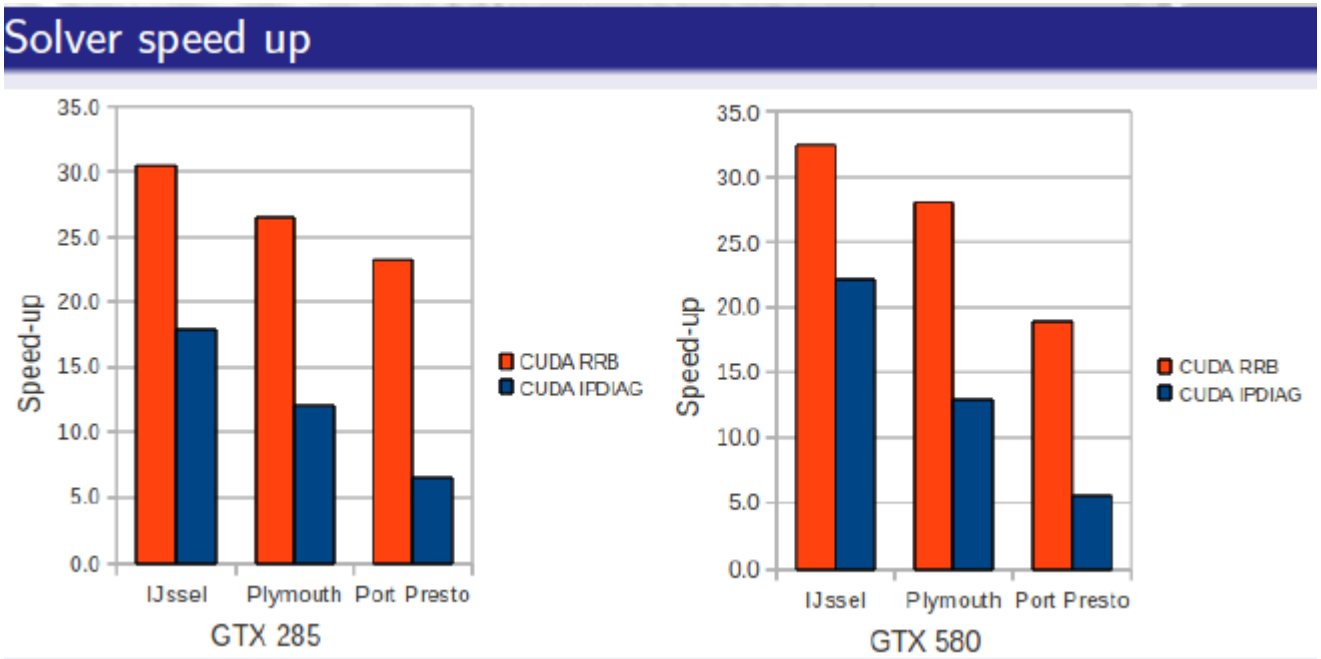
Problem with memory access

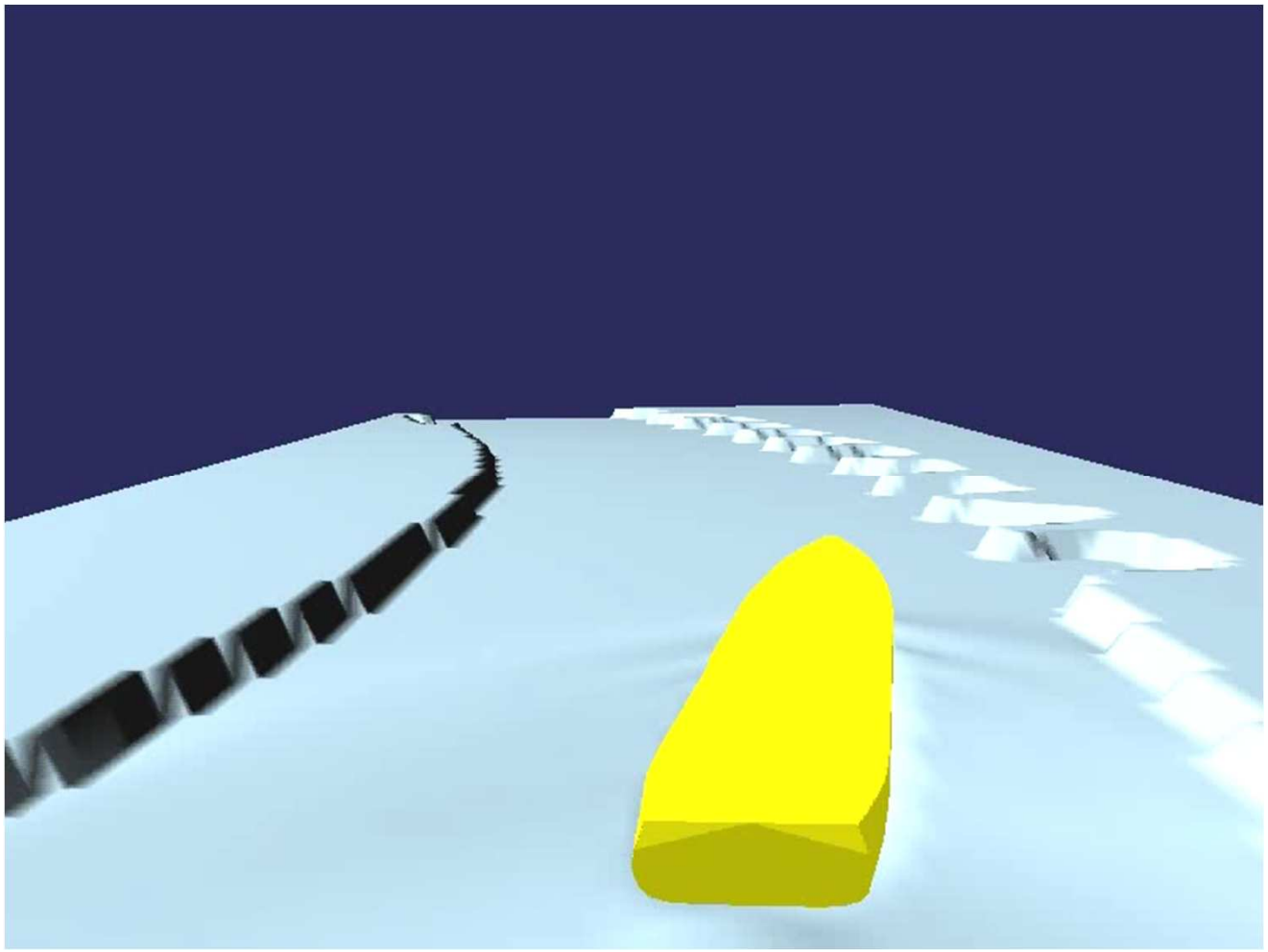


Good idea



Results


Solver speed up
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Speed-up
IJssel
Plymouth
Port Presto
CUDA RRB
CUDA IPDIAG
GTX 285
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Speed-up
IJssel
Plymouth
Port Presto
CUDA RRB
CUDA IPDIAG
GTX 580



Ship Simulator

Future

MARIN

M.Sc.-thesis research

Interactive waves for real-time ship simulation

in collaboration with MARIN

Background

MARIN (Maritime Research Institute Netherlands) provides ship manoeuvring simulators that offer a variety of maritime operations for virtually every type of ship and propulsion. The current computational model for the wave field is based on wave spectra, that are converted to time signals through Fourier transformation. This has the benefit of being deterministic in time and location and therefore is easy to implement on our distributed simulation systems. However, this model is not interactive, that is diffraction, reflection, refraction and depth dependency are not taken into account. From a visualization point of view, the model is limited too. However, better visualization models (used in movies like Waterworld, Titanic, Perfect Storm) lack physical realism.

Some images of the current ship simulator. The waves do not yet interact with ships and their environment.

MARIN wishes to use the so-called Variational Boussinesq Model to compute and visualize the wave field. This physically realistic model does provide interaction with objects, diffraction, reflection etc.

Two previous MSc Thesis projects (by Elwin van 't Wout and Martijn de Jong) have brought us to the point where it is possible to calculate real time the wave field using a uniform mesh consisting of 1,000,000 cells of constant size. For 5m cells, this results in a total simulated area of 5 x 5 km. To be useful in our manoeuvring simulator, a finer grid and/or larger domain are required and this still needs to be computed in real time. The current code uses parallel computations on the GPU.