Complex Water Effects at Interactive Frame Rates

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Complex Water Effects at Interactive Frame Rates

Simulation

- ring waves (gravity and capillary waves)
- Kelvin ship wakes (angle of 38°)
- wind waves, etc.

Display

- geometry of water surface
- reflections of sun and sky (Fresnel)
- caustics with shadows in them
- refraction of ground and caustics

Former Work

A quarter of a century
of water simulation
in computer graphics:
1986: Fournier/Reeves and Peachey

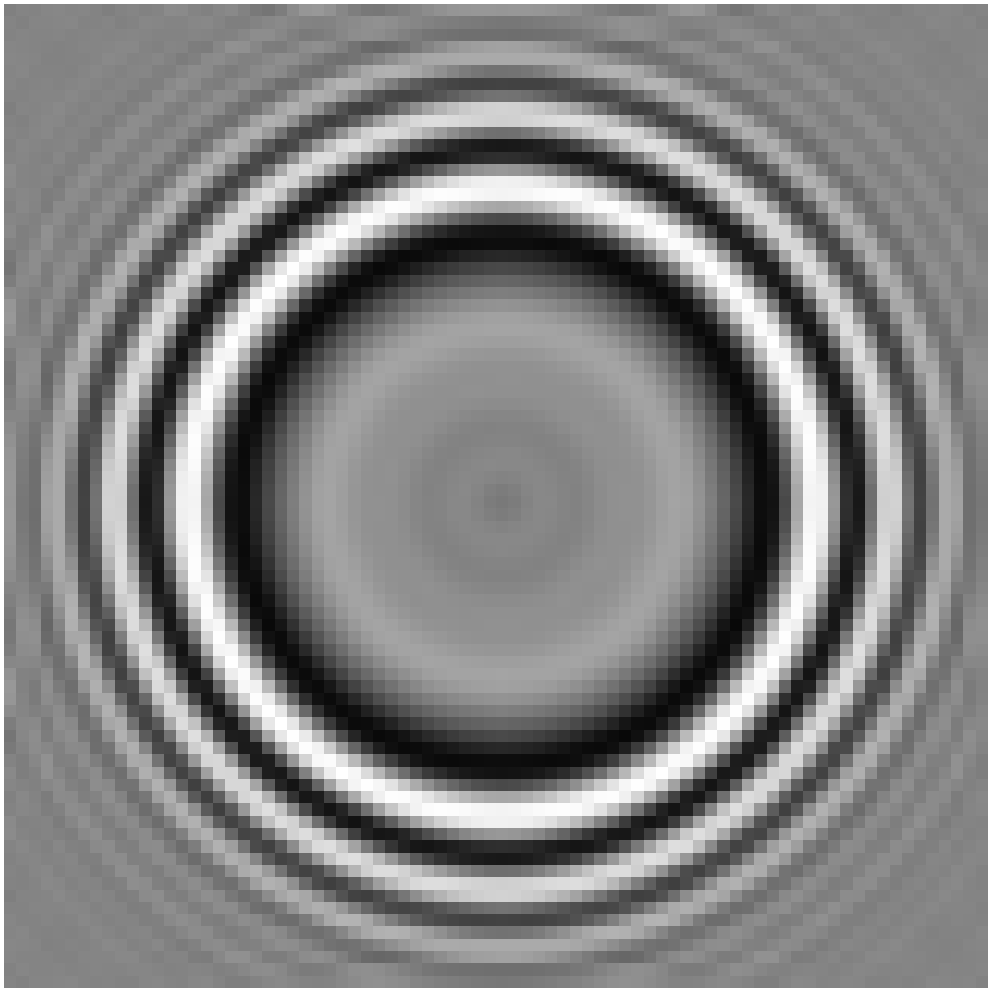
Commercial Products:

- Areté RenderWorld, Psunami, …
- Alias|Wavefront Maya 4.5 Fluid Effects
- …

Simulation

Simulation: Propagation of Waves

Linearized PDEs: Convolution with fixed circular wave, determined from hydrodynamics



Fast convolution (512 x 512) through FFT

Simulation: Ship Waves

Sum ship waves produced
between one time step and the next:

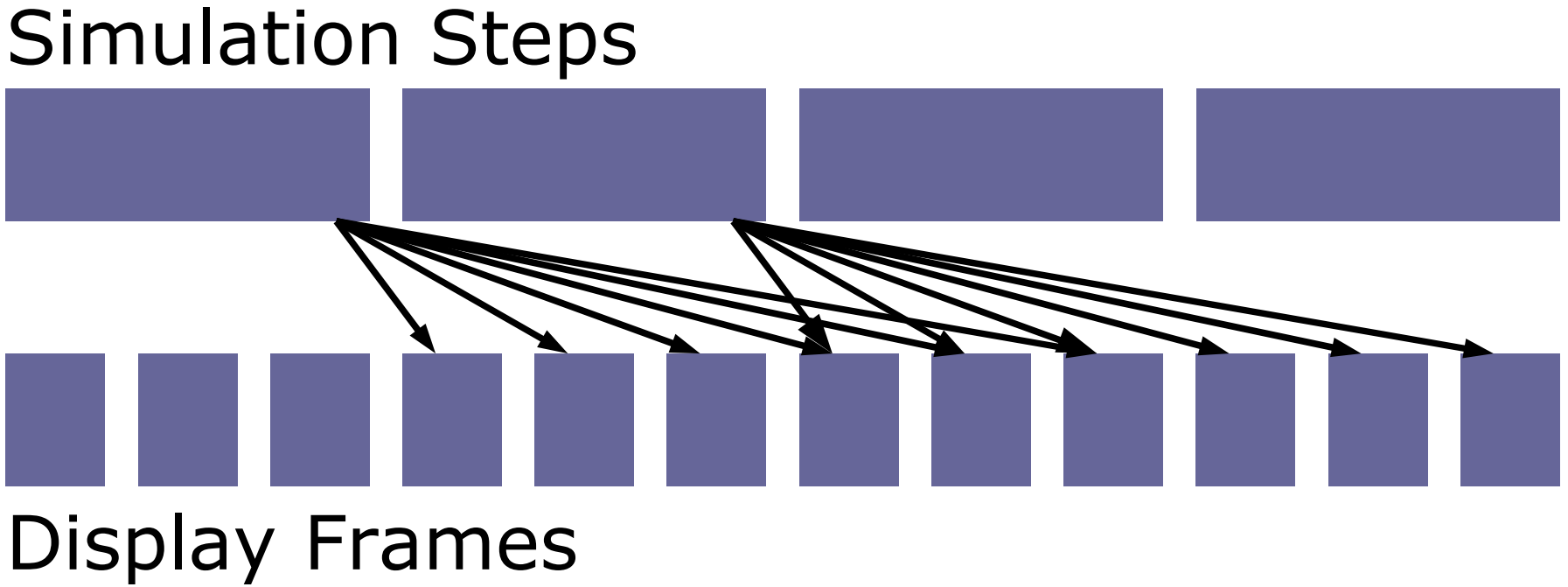
convolve with profile
of ship at last time step

+

convolve with profile
of ship at next time step

Simulation: Tripling the Speed

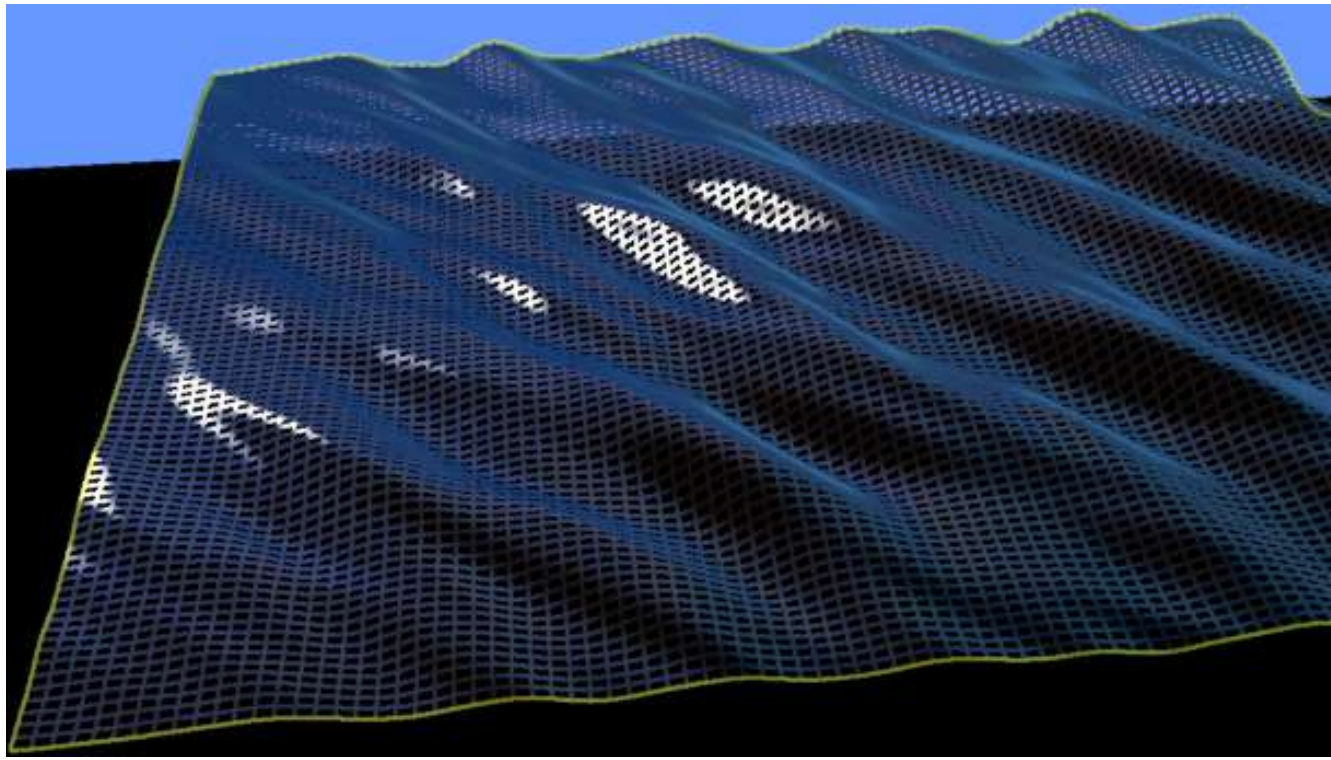
Run simulation at triple speed,
interpolate wave field for intermediate steps
(cubic interpolation using derivative)



Display

Display: Vertices vs. Texels

For efficiency
less geometry,
more textures

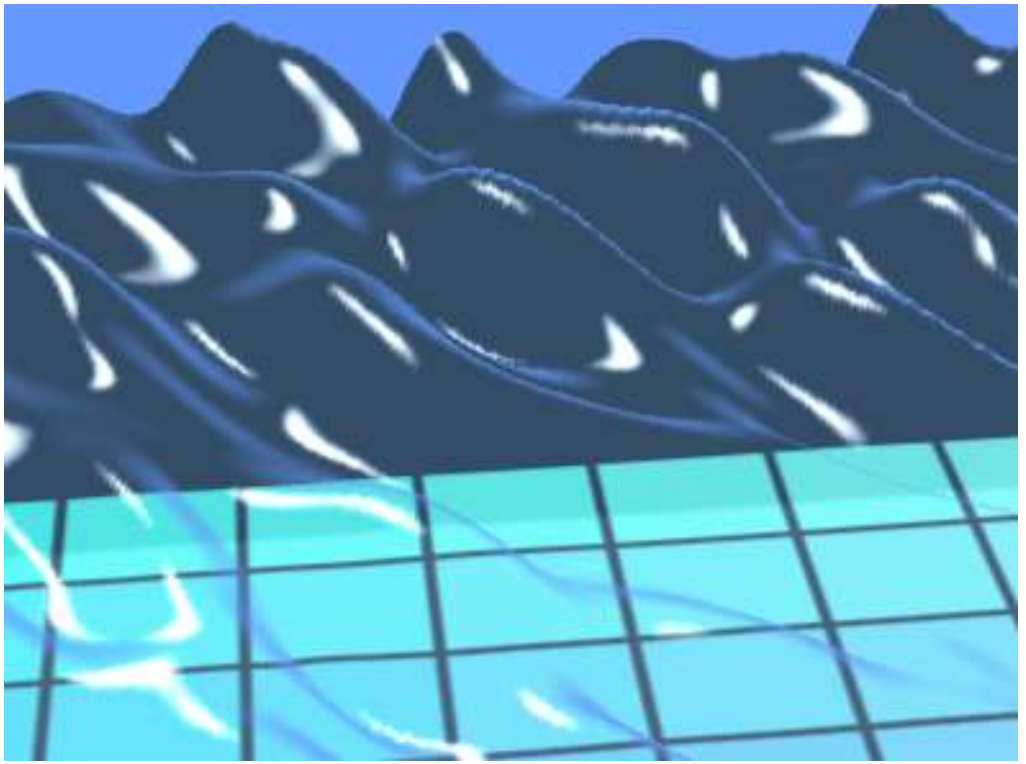


- Water surface
  as 95 x 95 x 2 triangles,

- Textures (multi-texturing, pixel shader)
  at 384 x 384 texels resolution

Display: Water Textures

- **Refraction**
  per vertex:
  influence
  of water height,
  per texel:
  influence
  of normal vector



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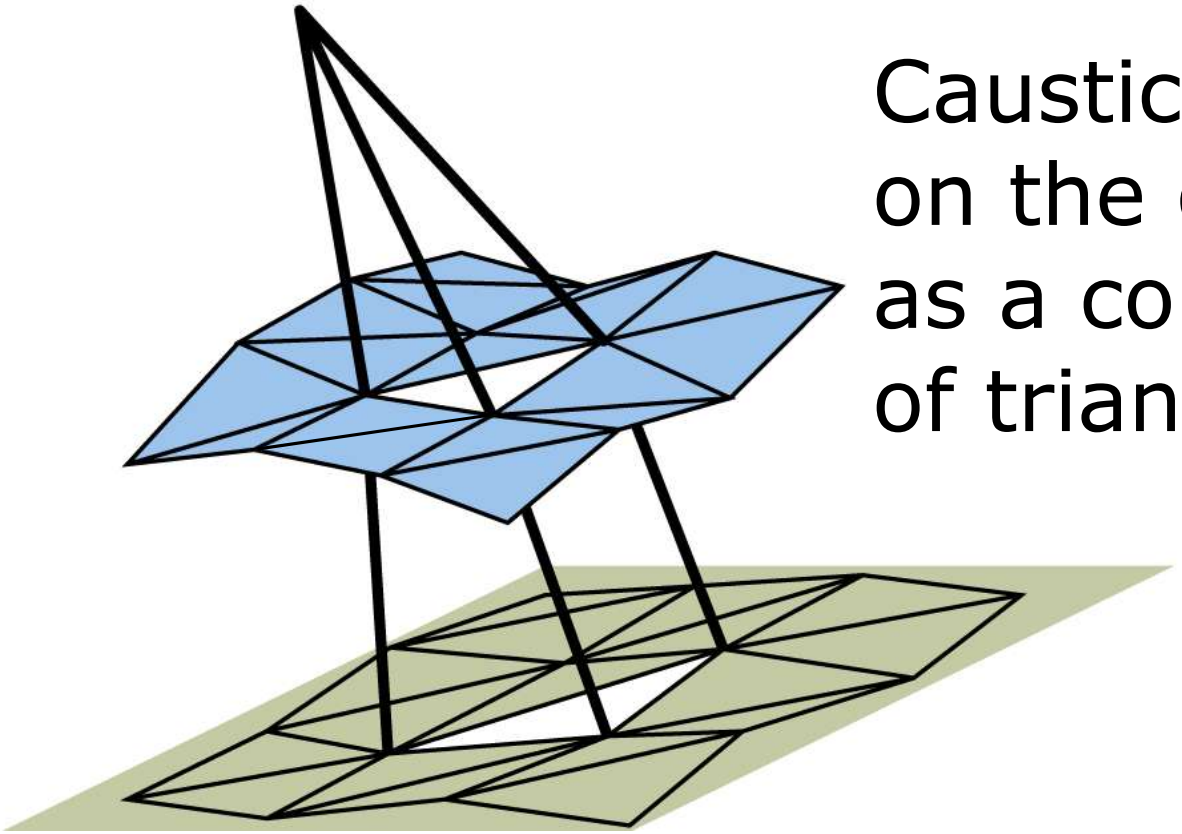
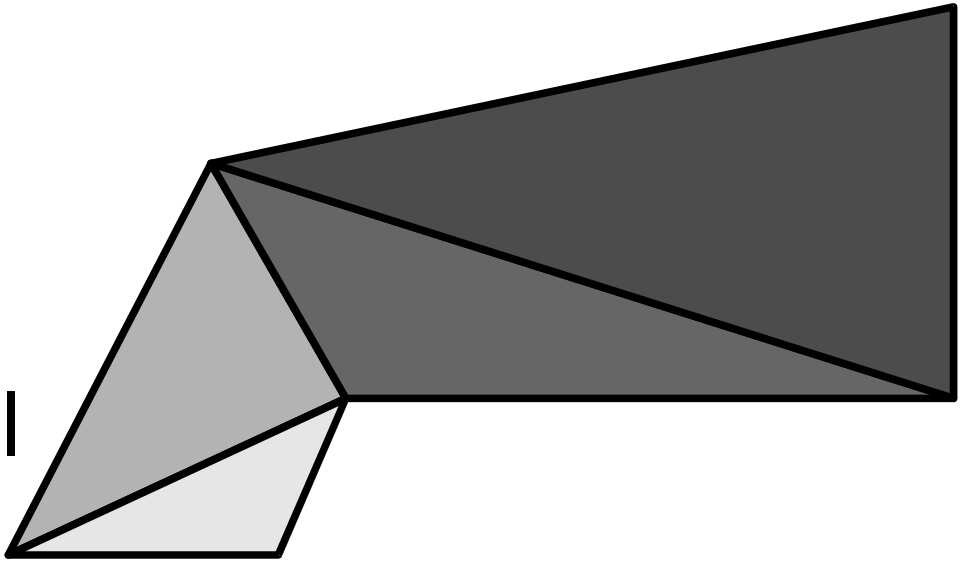
- **Reflection** of sun (Phong)
  and sky (Fresnel effect)
  as textures calculated on the fly

Display: Caustics



Caustics
on the ground
as a collection
of triangles

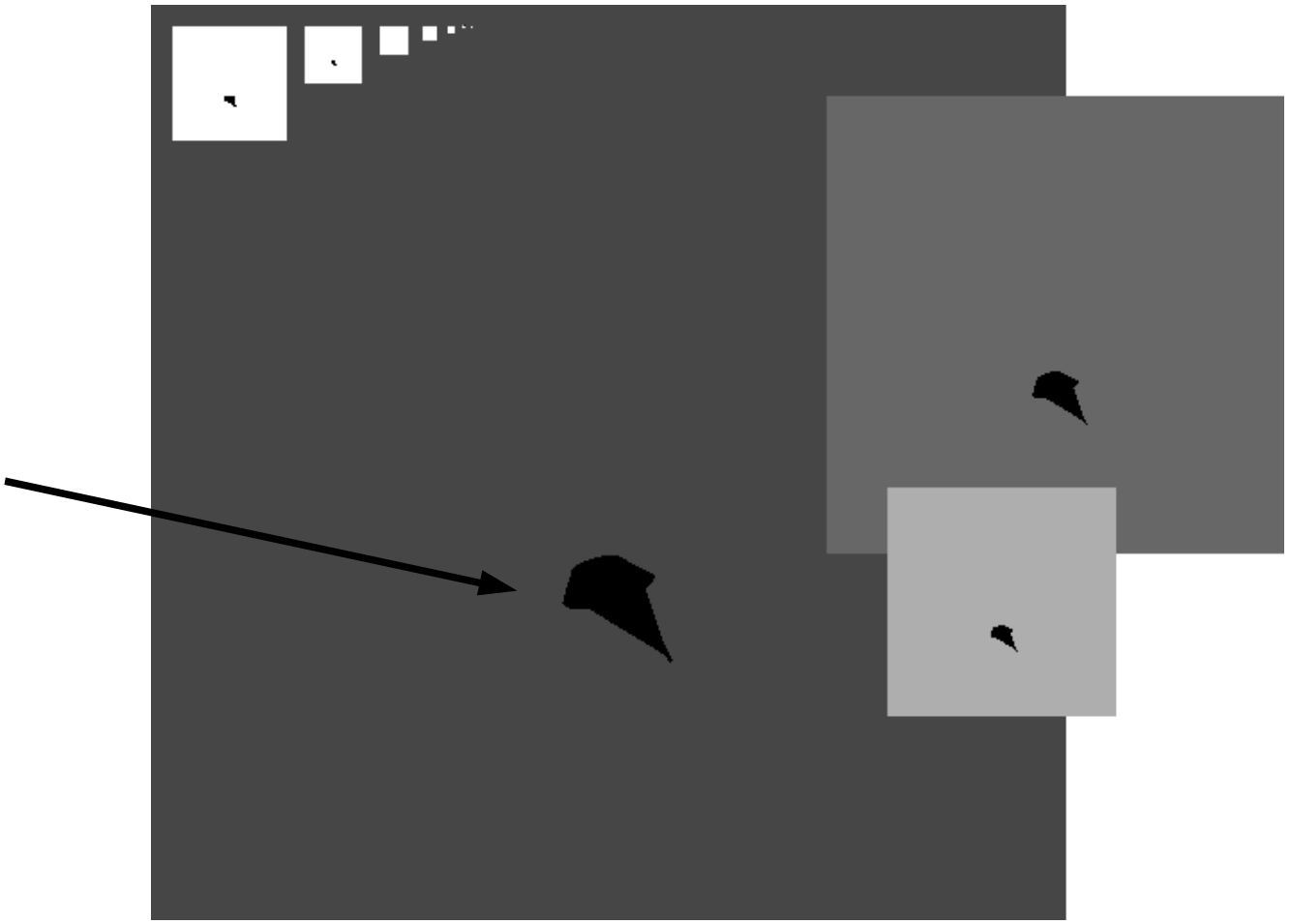
Illuminance
inversely
proportional
to area



Display: Caustics

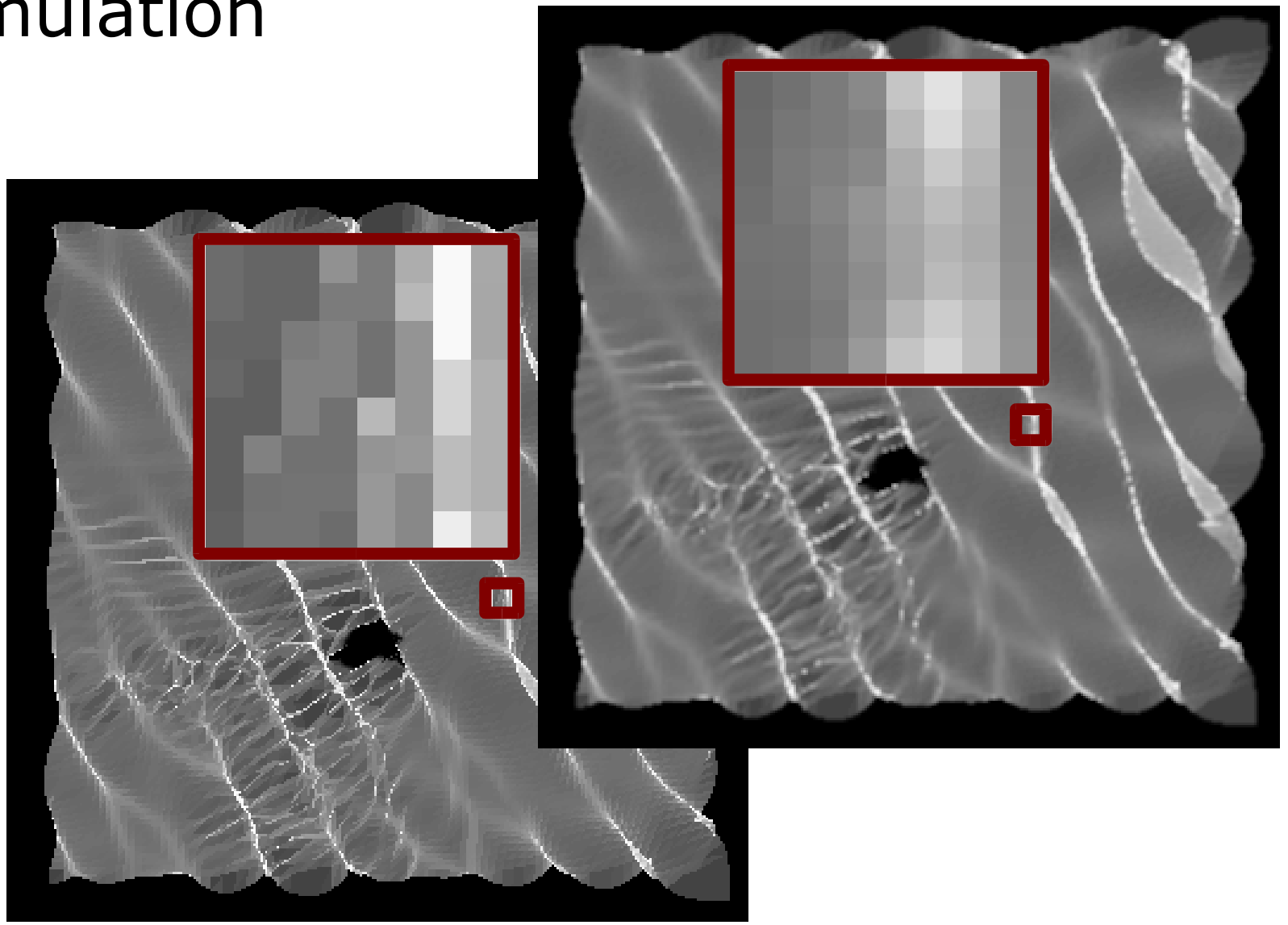
The graphics chip can compute
the area dependence by itself:
Use an appropriate MIP map texture.

Shadows
projected
on the fly



Display: Caustics

Blur by emulating an accumulation buffer



Performance, Outlook

Performance

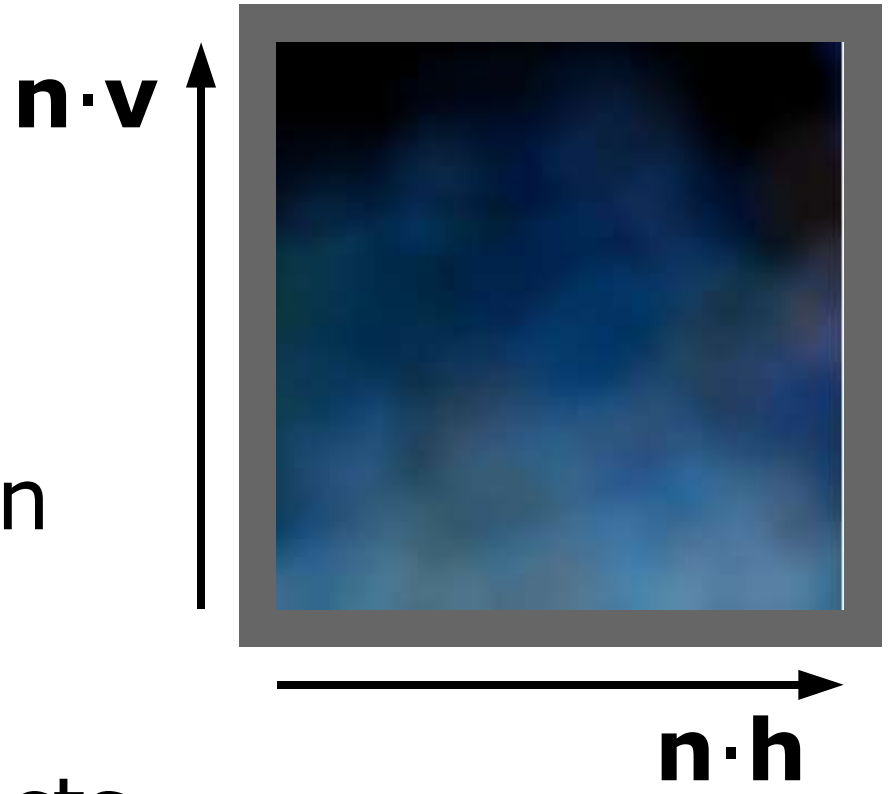
Wave Propagation (1/3 Step)	52 ms
Generate Ship Waves	6 ms
Generate Caustics; Blur	18 ms
Generate Reflection Textures	51 ms
Render Water Surface	42 ms
total	**170 ms = 6 fps**

System:
Pentium®-4 at 2,5 GHz
nVidia® GeForce® 4 Ti 4200

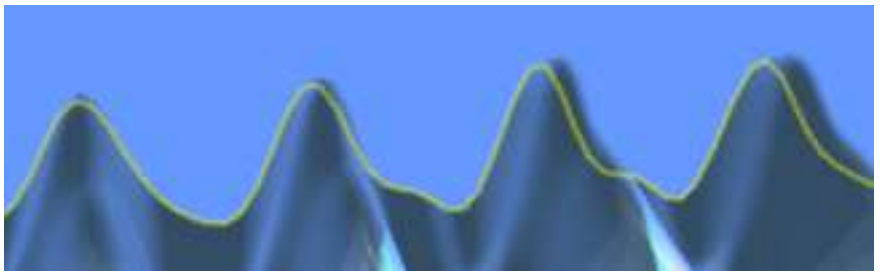
Outlook

Future Work:

- Accelerate texture generation and rendering



- Include more effects of non-linearity



- Include refraction and reflection of waves