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# Realtime Particle System Simulation and Rendering in Embedded Systems

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- Smartphones / tablets (so called embedded systems) will replace PCs in consumer households
  - Already happening

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PCs in the future will only be used for work, and probably hardcore gaming



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- PCs in the future will only be used for work, and probably hardcore gaming
- Rapid growing market for games on embedded systems
  - Considered to be one of (if not: the) most important market
  - Mainly small, casual games, but even many with advanced graphics

# **Motivation**

- Embedded systems: performance constrained
  - Efficiency optimized, not performance optimized like PCs
  - Also: very high resolution screens, no upscale

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- Different architecture as PCs / gaming consoles
  - Shared memory, shared bus between ALL the components
  - In comparison to PC only limited distributed memory (e.g. caches, in case of the GPU in the Nexus 10: <=256 kbytes)</li>
    => need to make the most of it





#### Ice Storm: cross platform benchmark



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Ice Storm: cross platform benchmark

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Nexus 10 as used during this project: 8006





Ice Storm: cross platform benchmark

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- Nexus 10 as used during this project: 8006
- NVIDIA GeForce GTX 660: 137246

=> more than 17 times faster!

# Background

- Particle effects in computer graphics
  - Water, smoke, fire etc.
  - Navier-Stokes based solutions, e.g. "Simple and Fast Fluids"
- Current games for smartphones / tablets
  - Particle systems
  - Basically animated billboards moving in predetermined or pseudorandom way



# **Our contribution**

First work on effects based on simulated particle movement on embedded systems

Based on a novel, forced-based motion model
 No need for additional, space-consuming pressure field
 Simulation completely done in 2D



#### Particle Fields





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#### **Particle Fields**



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- 4 different forces
  - Diffusion
  - External forces (e.g. gravity)
  - Inertia

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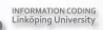
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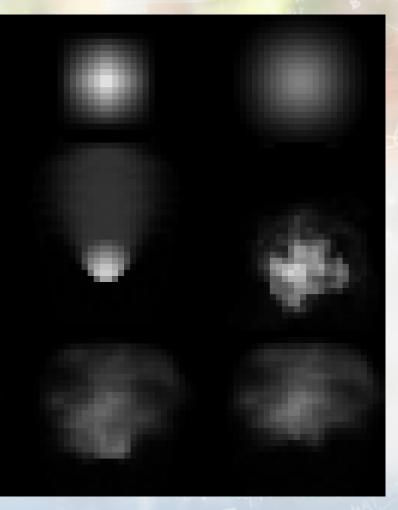
- 4 different forces
  - Diffusion
  - External forces (e.g. gravity)
  - Inertia

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- Random
- Combined using different weights for each



#### Force based motion



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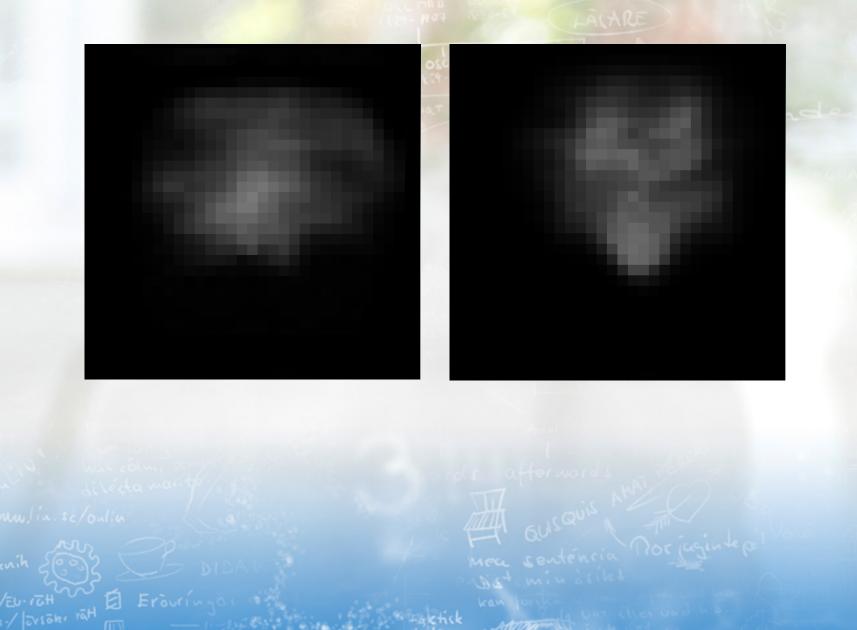
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#### Force based motion





#### Results

	Size of particlefield	Reference (time/ms)	Simulation (time/ms)	Rendering (time/ms)	Est. FPS
Nexus 10, resolution: 2560x1600					
Fire	32x32	4.89	3.17	26.7	36.3
Water	64x64		3.59	43.2	22.3
Smoke	64x64		3.93	11.4	84.3
iPhone 5, resolution: 1136x640 (preliminary)					
Fire	32x32		3.4	34.2	28.2
Water	64x64		6.3	47.6	19.7
Smoke	64x64		7.6	7.2	138



# Conclusion

Effects based on simulated particle movement for games in embedded systems

Based on novel, force-based motion model

- Faster than fastest Navier-Stokes (by 35%)
- Much less data (up to 80% less)
- Easy to configure for the designer
- Allows fast particle spreading



# Conclusion

#### Future work

- Optimize the code
- More unified approach
- Improve visual quality

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