

# GPU Programming in Computer Vision

## Preliminary Meeting

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# What you will learn in the practical course

- Introduction to NVIDIA CUDA Framework
- Introduction to parallel computing on GPUs
- How to parallelize basic computer vision algorithms in CUDA/C++
- Practical project experience
- Team work, presentation skills

# Important Dates

- Preliminary Meeting: 3. February 2017 (today)
- Registration in the matching system on 3. - 8. February 2017
  - List your preferred practical courses
  - Send an email to cuda-ss17@vision.in.tum.de describing your prior knowledge in C/C++, Computer Vision/Image processing along with a short motivational statement
- Matching Results: 15. February 2017
- Only assigned students are allowed to attend !!!
- See docmatching.in.tum.de/index.php/schedule

# Course Organisation

- 4-5 weeks block course in the semester break (beginning of September - mid of October)
- 1 week lecture and exercise session
- 3 weeks project phase
- Our computer lab will be open for students
- Computers are equipped with recent GPUs (GTX 750), one for each student.
- Students will work in groups: 24 students, ideally 8 groups, each has 3 students.
- Every group will be assigned to one advisor.

# Course Structure

- First Week
  - Theoretical lecture in the morning
  - Hands-on programming exercises in the afternoon
- Following 3-4 weeks
  - Project phase, one project to each group
    - Your own ideas,
    - Project Proposals, any related topic to Computer Vision, Image Processing, Machine Learning
- Final presentation of the projects

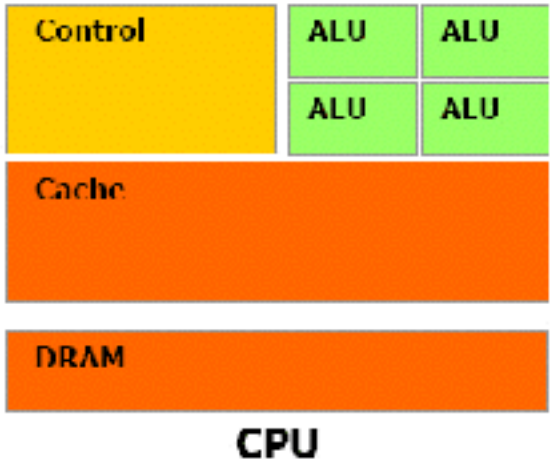
# Evaluation Criteria

- Successful completion of the exercises (0,3 bonus)
- Gained expertise in CUDA/parallel programming
- Quality of your final project
  - Successful completion of the project
    - Projects will be evaluated by the project advisors
  - Your talk

# Regular Attendance Is Required

- Attendance at classes/exercises is mandatory
- In case of absence: Medical attest
- The practical course is intended as a 4 week „full-time“ project

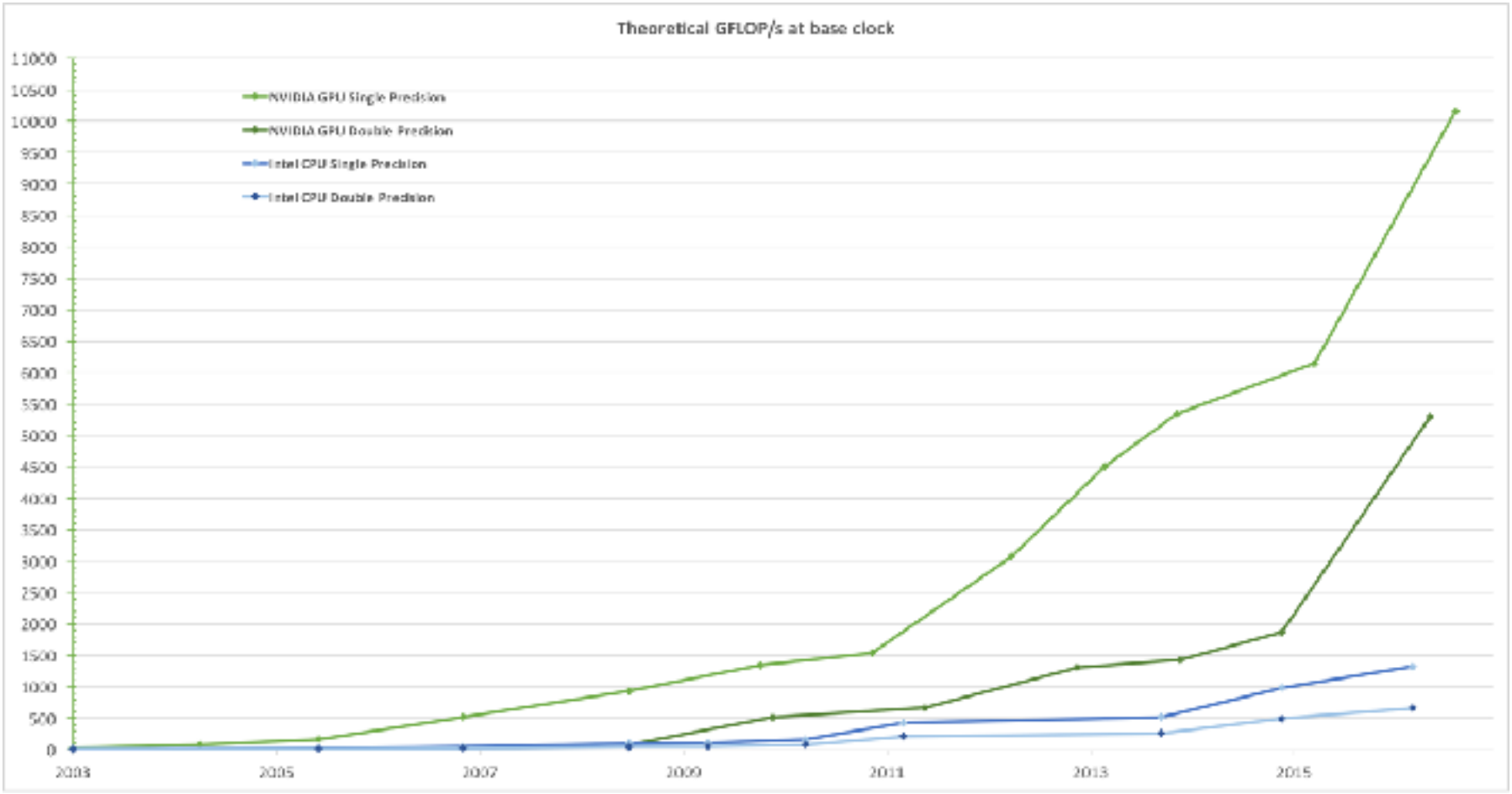
# Motivation on GPU programming




CPU: 4 - 32 cores

GPU: 3072 cores

# CPU vs GPU

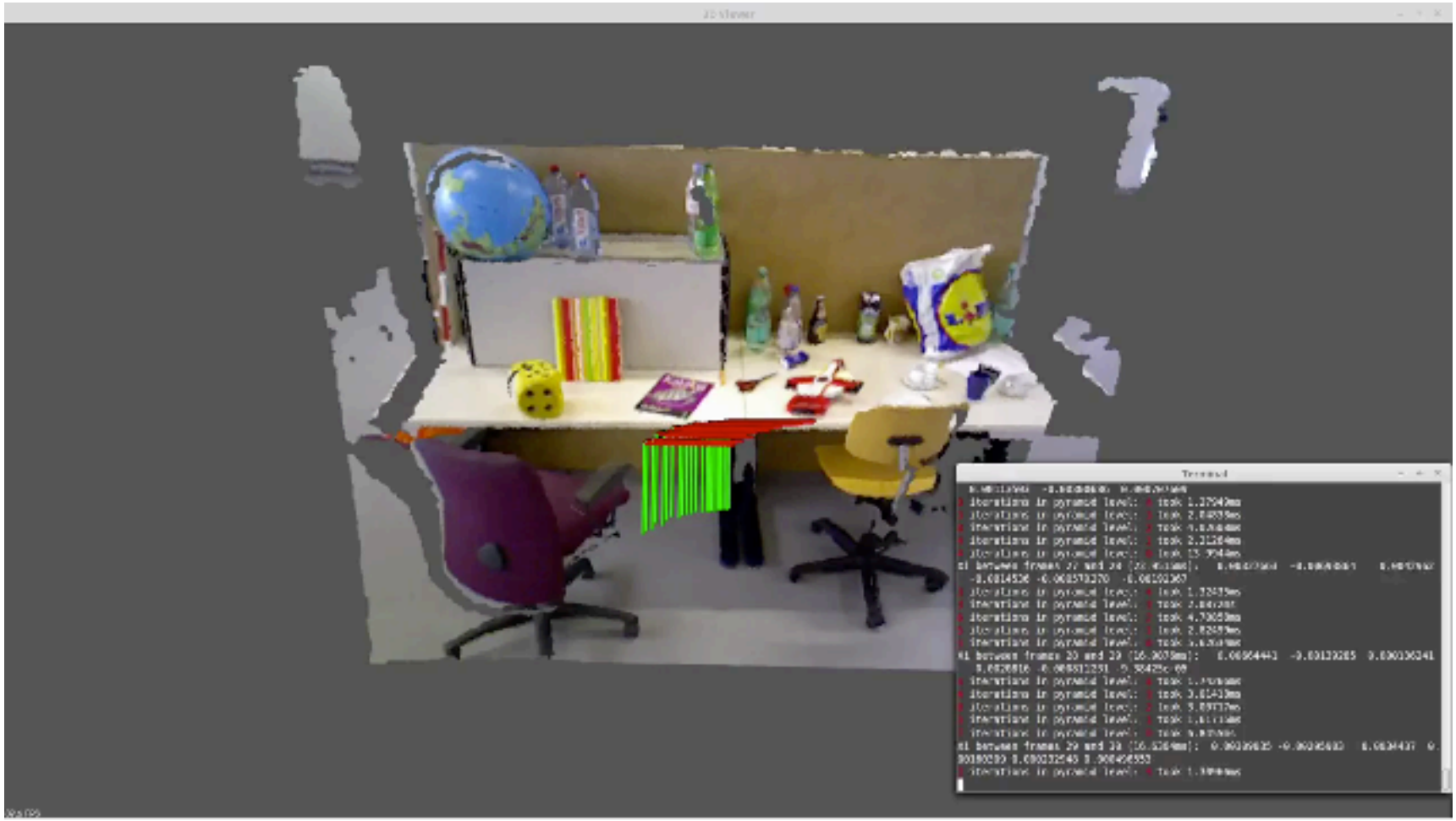

Theoretical GFLOP/s at base clock
NVIDIA GPU Single Precision
NVIDIA GPU Double Precision
Intel CPU Single Precision
Intel CPU Double Precision
11000
10500
10000
9500
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2003
2005
2007
2009
2011
2013
2015

# Motivation on GPU programming

- Allows you to do some cool stuff!
- Student projects from the previous years…

# High Resolution Maps from Aerial Footage

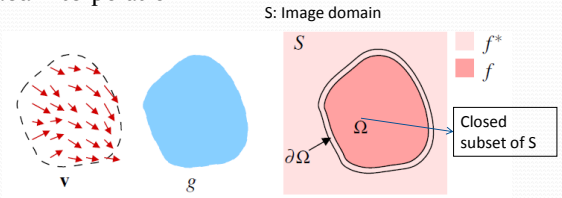
# Dense Visual Odometry



# Poisson Image Editing

## Poisson Solution to Guided Interpolation

- Guided Interpolation




Guidance vector field

Gradient field of a source function

f*:Destination function
f: Unknown function



## Properties of the Poisson's Equation

$$\min_f \iint_\Omega |\nabla f - \mathbf{v}|^2 \quad with \quad f|_{\partial\Omega} = f^*|_{\partial\Omega}$$

$$\Delta f = \mathrm{div}\mathbf{v} \text{ over } \Omega \text{ with } f|_{\partial\Omega} = f^*|_{\partial\Omega}$$

$$\mathrm{div}\mathbf{v} = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}$$

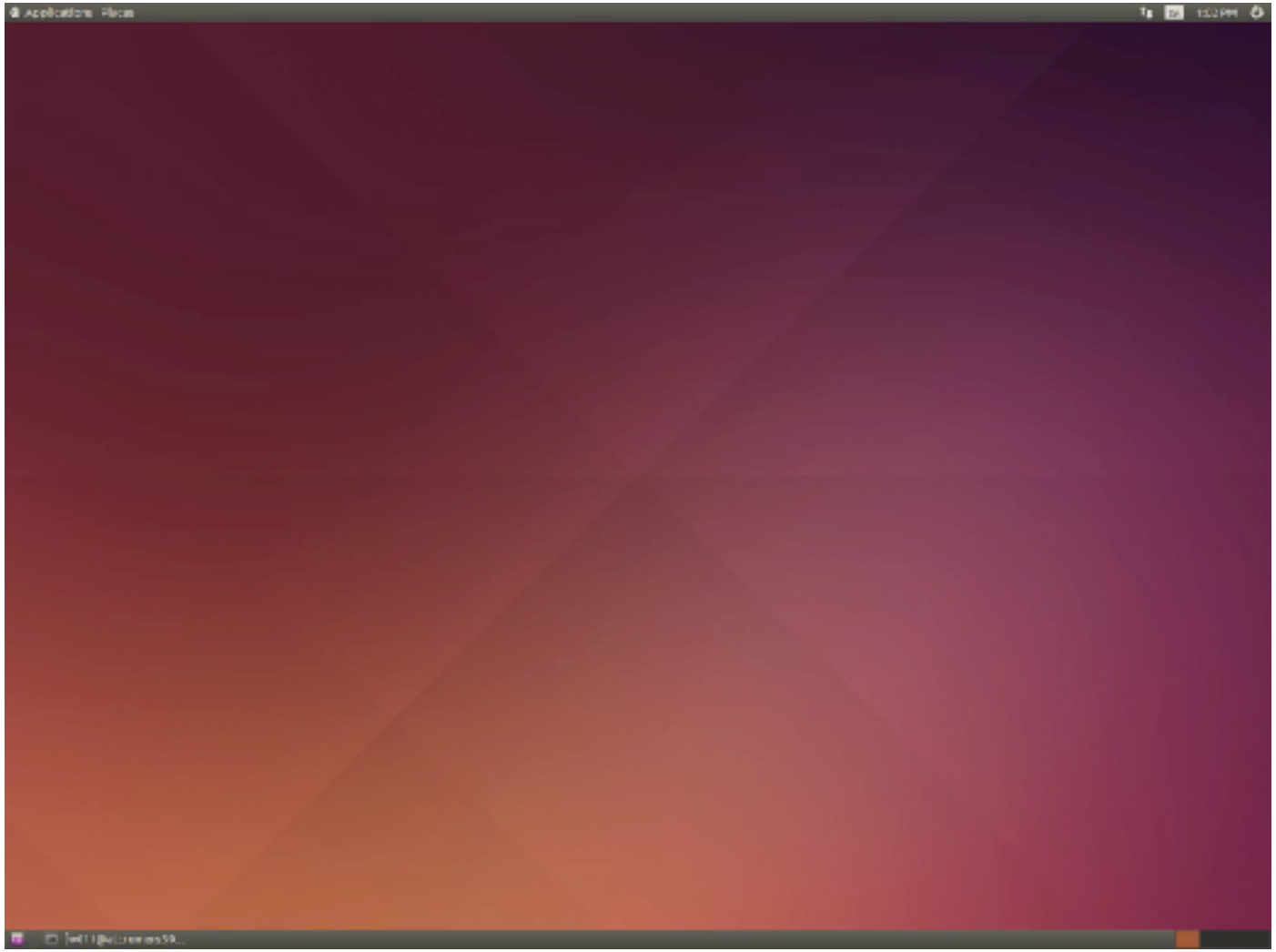
- Second-order variations extracted by Laplacian operator are the most significant "perceptually"
- Scalar function on a bounded domain is uniquely defined by its values on the boundary and its Laplacian in the interior
  - Poisson equation therefore has a unique solution



## With source guiding gradient

Source (That's Me) Target Output

# Depth Adaptive Super Pixels



# GPU Accelerated Cryo-microscopy

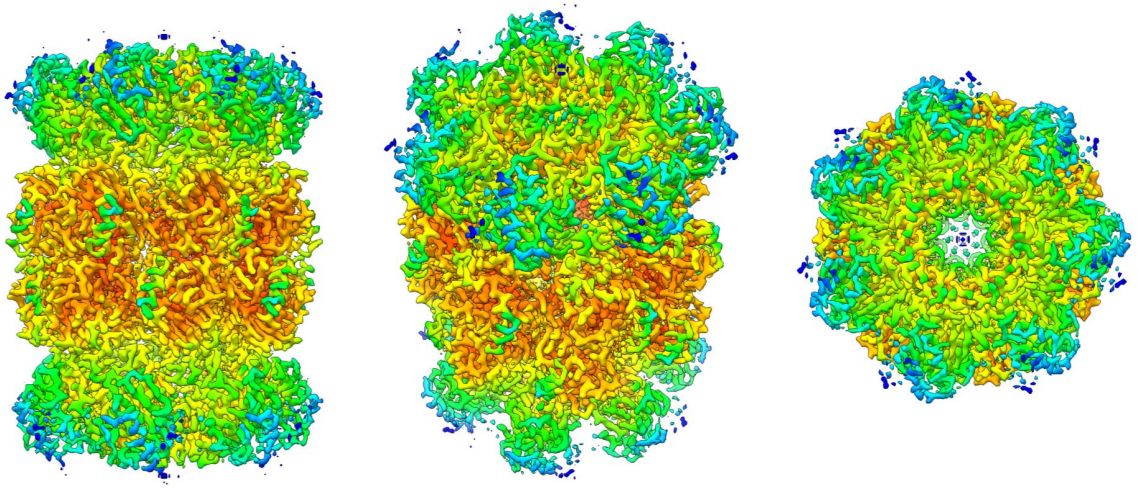
Results: Speed

1:100

GTX 980 Xeon 2640 v3 cores

…or 1:42 when using AVX on CPU

## Results: Validation



World's first 2.7 A proteasome density from EM data

(previous record: 2.8 A)

# Kinect Fusion

# Enjoy the practical course!