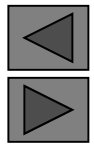
COMPSCI 773-2018

- Lecturers: A. Prof. Patrice Delmas (303.418)
  Prof. Georgy Gimel'farb (303.417)
  Dr Yen Chen (303.528)
- Lecture time: Tues 10-11am G15 Thurs 11am-2pm or 12-2pm B05
- Up to 33 hours of lectures and 9 hours in-class practical assignments
- 3 in-class assignments, a demo (experimental data gathered in class, report due later) and 1 at-home assignments
  - A1: written assignment completed at home
  - A2: calibration without distortion (in-class + home)
  - A3: calibration with distortion (in-class + home)
  - A4: rectification and stereo matching (in-class + home)
  - A5: Full system demo + final report (A2-A3-A4 recompiled)
- Marking:
  - 40% Final exam
  - 60% Lab work (5 individual assignments



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1st assignment: linear algebra, 2-3D geometry,

10% – due: 19.03.2018

2nd assignment (in-class): distortion-free camera calibration, 15% – in class: 22.03.2018, report due: 26.04.2018

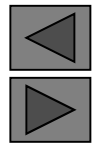
3rd assignment (in-class): camera calibration, gradient descent, 15% – in class: 26.04.2018, report due: 16.05.2018

4th assignment (in-class): rectification, stereo matching algorithm implementation, depth map construction,

10% – in class: 17.05.2018, report due: 03.06.2018

Demo (in-class): full system design demo 5%, individual assessment 5%

– in class: 31.05.2018



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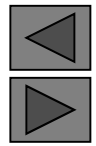
- **Individual assessment:**
  - **Interaction with Patrice during assignments**
- **Assignment reports (what's in it):**
  - **Minimal description of available technology, techniques (lit. review)**
  - **Presentation of your solution (theory and methods)**
  - **Experiments and results**
  - **Analysis and conclusions**
  - **Follow scientific writing guidelines**



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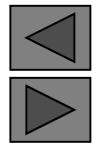
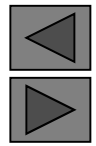
- The report should look like a research report with references
  - Justified explanations on the chosen solutions, graphs, results

  and
  - Critical assessment of the outcomes
- Programming
  - Windows C, C++, Matlab, ImageJ, Java, Python
  - OpenGl, CUDA, Gtk, OpenCV
  - You are allowed to use external libraries but you have to make sure we are aware of it (in your report write down which programs are yours and which ones are not)
  - You may be asked to pass your code to other students for the next assignment → This is a good outcome for your work
  - If you use other students' code you MUST state it in your report



The project: 3D mapping using UAVs

- A2
  - Calibration without distortion
- A3
  - Calibration with distortion, calibration improvements
- A4
  - Improve calibration accuracy, rectification, stereo matching
- Full system design-demo
  - Calibration+rectification+stereo-matching



What is available and what you will have to do

US:

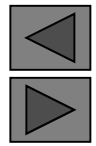
- 3D camera
- Calibration object
- Quadcopter

YOU:

- Code in C, C++, Java or else
- A very strong personal effort
- Good planning
- Fast-tracking “learning ➡ application”

OUTCOME

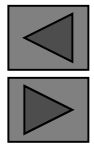
- You will undertake work at the top-edge of today’s research
- You will gain a unique experience in applied Computer Vision



What is expected

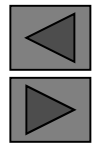
Projects at the edge of research development: neither easy nor simple

- A great deal of work is required but: (1) you will learn a lot; (2) this could count as work experience in an expending IT area; (3) you can show what you are worth without having to fear too much about the final exam
- The exam will encompass all that will be lectured **+** project-related questions
- It is not a good idea to concentrate on a very restricted part of the project as this will penalise you by the end
- If you like the projects you can continue towards the same directions for COMPSCI 780 / MSc studies
- If you think COMPSCI 773 is too hard for you we can offer a COMPSCI 780 project along the same directions



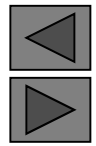
What you should know or learn very quickly

- C, C++, Java programming
- Confidence in mathematical skills (linear algebra, optimization techniques - 369)
- Basics of Image Processing (373)
- To learn quickly (by yourself)
- GUI design (just the basics) --optional
- The rest we will teach you…



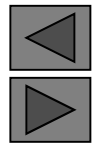
Course contents (ideally)

- Introductory lecture
- Segmenting binary images
- Feature extraction
- Image matching
- Stereo image matching
- 2D and 3D vision geometry Camera calibration
- Stereo calibration
- 3D scene description / understanding
- Real-time image processing
- Rectification of stereo pairs
- Colour discrimination
- Features classification: PCA-LDA
- Higher level statistical approaches
- Course overview and final demo



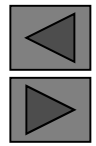
Assignment 1

- Support homework on linear algebra and simple2-3D geometry material preparation
- Mostly based on past-years exam questions
- Very short time to complete
- Must prepare yourself from today
- Out next week



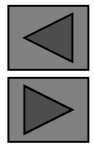
Assignment 2

- **Prepare the theoretical material required (a home)**
  - Linear algebra, lecture notes
- **Acquire still images from a camera (in-class)**
  - Acquisition of calibration object (we bring one or you design one)
- **Proceed through distortion-free calibration (in-class)**
  - Input 2D and 3D corresponding points
  - Produce the over-determined system
  - Produce the pseudo inverse
  - Recover the calibration parameter
- **Analyse results (home/in-class)**
- **Produce a short report (6-8 pages + images/references)**



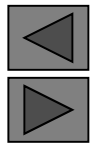
Assignment 3

- **Prepare the theoretical material required (at home)**
  - Optimisation techniques, read about Tsai or other calibration techniques
- **Acquire still images from a camera**
  - Acquisition of calibration data (**in-class**)
  - Acquisition of stereo data
- **Proceed through calibration including a distortion model**
  - Complete distortion-free calibration
  - Use gradient descent to obtain all camera calibration parameters
- **Analyse results (home/in-class)**
- **Produce a short report (6-8 pages+images/references)**

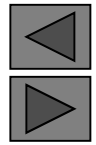


Assignment 4

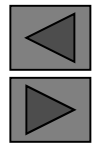
- **Prepare the theoretical material required (at home)**
- **Calibrate your stereo system using A2 and A3 outcomes**
- **Matching / stereo matching**
  - Using camera data
  - Implement a simple window-based correlation-based matching algorithm
  - Produce a depth map
  - Work on the implementation of a stereo matching algorithm
- **Work on the final report encompassing all A2-3-4 material. Write it as a conference submission-like report (IEEE guidelines)**
- **Latex format preferred (send us all sources)**



Outputs of A4 with stereo GoPro Hero3+ and a UAV



Input data

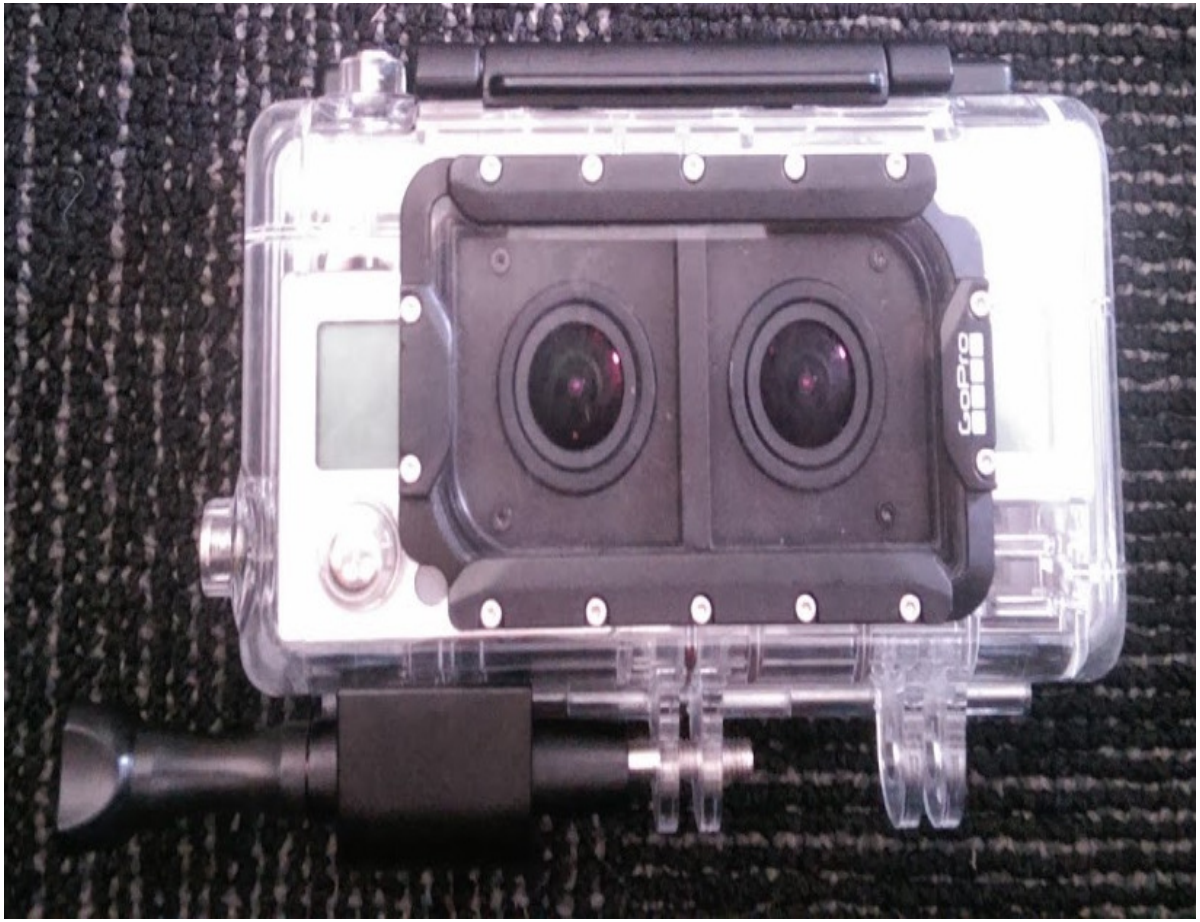


Synchronised stereo pair of GoPro Hero3+

35 mm baseline

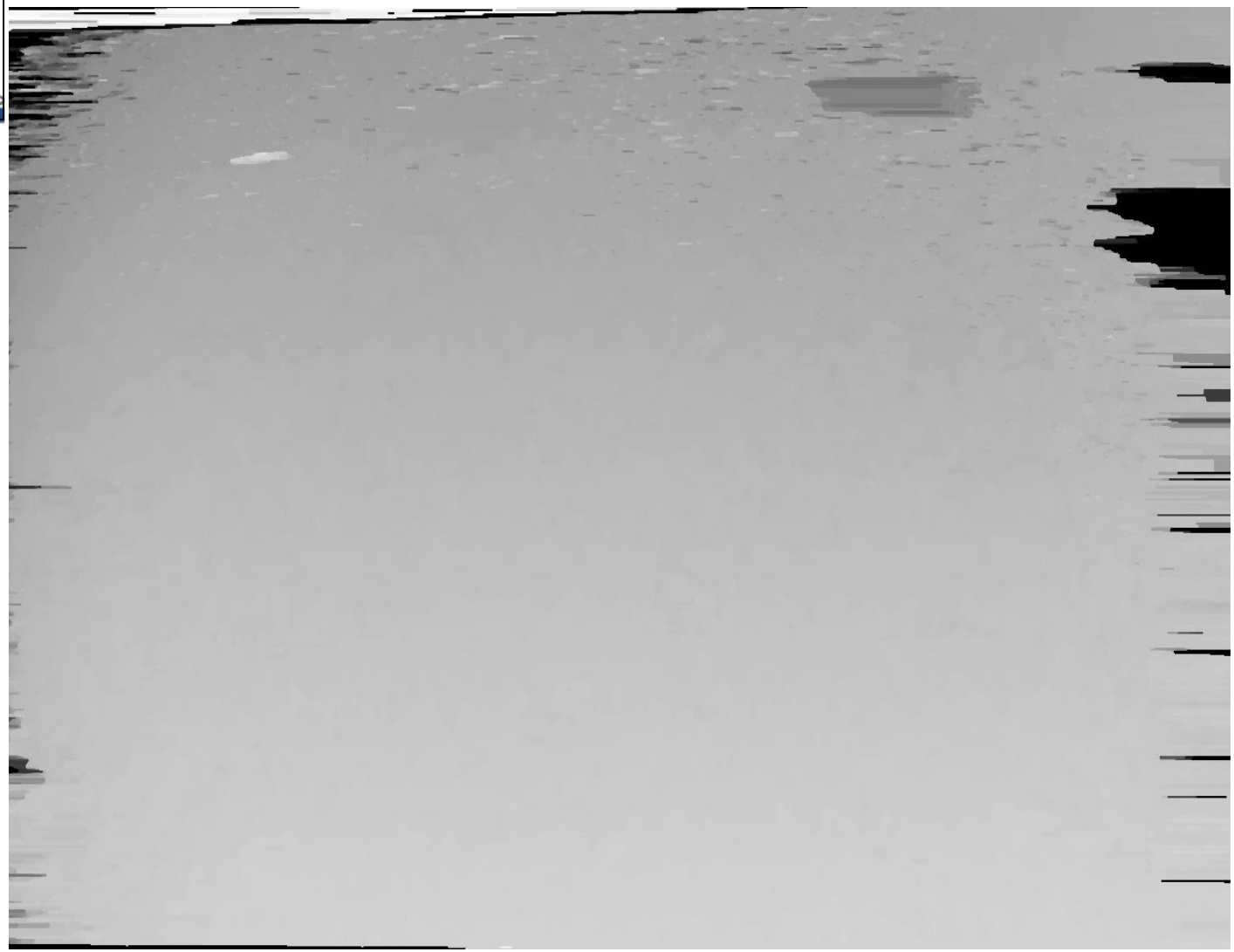
Full HD resolution at 30 fps

Mounted underneath quadcopter and flown over mudflats



Input stereo pair of images

Undistorted and rectified images

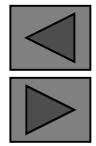


GoPro Hero 3+: grayscale depthmap
(block matching + 2 it. dynamic programming, via IVS website)

GoPro Hero 3+: equalized depthmap (histogram equalization)

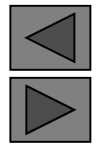
Final demo

- Produce an in-class demo integrating your A2-A3-A4 practical work (31/05/2018)
  - **Use A2-A3-A4 to acquire and process 2-3D images from calibrated cameras (in-class)**
  - **3D data display (tentative)**
  - **Perform a real-time demo**
- Prepare yourself for a 1-on-1 interview with Patrice-Trevor
  - Encompassing all material in the course



Field-trip in Leigh

- Funded by the Department of Computer Science
- Not compulsory but encouraged if keen on MSc/PhD studies
- We will go through some of the experiments performed as part of our collaboration with marine Science researchers
- It will happen over a week end either in May or after the class ends
  - Tentatively depart on a Friday after-class 6pm
  - Return end-of-day Sunday
- Accommodation (bunk beds) and Catering at Leigh marine Science campus



Questions ?

- **What now**
  - **I am very keen to help and answer questions:**
    - Better ask after lectures and during tutorial hour if any or in-class assignments.
    - This is a research-based project: I am keen to learn from you.
    - *My advice*: read research articles, self-learn, respect assignments requirements, but you are very welcome to explore alternative solutions once you have completed required outputs.
    - Start to work on this today