# Robotic Vision Summer School
# Preliminary Tutorial Curriculum
# February 2020



## Rationale

Robotics, computer vision and AI are revolutionary and transformative technology that will influence all areas of society. This short course provides an introduction to robotic vision - a new discipline which uses computer vision and AI to solve core problems in robotics such as object recognition, manipulation and navigation.

## Aims

This short course introduces the fundamental principles and mathematical techniques that underpin modern robotic vision. This course is aimed at:

- First year PhD students in robotic vision or computer vision
- Industry practitioners working in the areas of robotics or computer vision

The course is conducted in summer school mode which allows for relaxed interaction with fellow students as well as senior researchers.

# Learning outcomes

On completion of this unit you will:

1. Understand fundamental algorithms in robot vision, control and learning
2. Use common tools and platforms to implement these algorithms
3. Apply these algorithms on a robot platform
4. Be aware of current open research problems and challenges in the field of robotic vision

# Learning approach

Instruction is through:

- 10.5 hours of lectures and interactive hands-on exercises. The lectures will be recorded and made available after the summer school.
- 7.5 hours of hands-on workshop where you will work in teams of 3 to put concepts from the lectures into practice on small vision-enabled robots

# Schedule and Contents

(insert link to schedule table here)

| Time | Topic | Contents |
|---|---|---|
| Sunday<br>20:00 - 21:00 | Welcome and Introductions | Overview of the course<br>Introduction to the interactive tutorial environment and software tools.<br>What is Robotic Vision? |
| Monday<br>9:00 - 10:30 | Introduction to Vision (A1) | Images and pixels<br>Pinhole camera model intro<br>Central projection imaging model, homogeneous coordinates, intrinsic matrix, camera matrix<br>Camera calibration<br>Image Features<br>Point features: position, scale and orientation<br>Feature matching between images |
| Monday<br>11:00 - 12:30 | Introduction to Geometry (B1) | Representing pose, rotation matrices, transformation matrices, SO(3) and SE(3)<br>Image geometry: image formation (camera matrice - extrinsic)<br>multiview geometry (epipoles, fundamental and essential matrices, RANSAC) |

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|---|---|---|
| Tuesday<br>9:00 - 10:30 | Robot Localisation (B2) | Lie group algebra<br>State estimation (planar)<br>Vision-based localization, mono SLAM, VISLAM (long range spatial awareness) (planar)<br>Structure from Motion, bundle adjustment, Extended Kalman Filter |
| Tuesday<br>11:00 - 12:00 | Introduction to Learning (C1) | Learning motivation<br>Classification vs Regression<br>Introduction to Neural Network fundamentals<br>Introduction to Graphical Processing Units |
| Wednesday<br>9:00 - 10:00 | Robotic Vision (A2) | Camera Motion and Optical flow<br>Visual odometry, scale ambiguity<br>Vision-based control: image-based, position-based |
| Wednesday<br>11:00 - 12:00 | Deep Learning (C2) | Deep learning architectures<br>Deep learning frameworks, tool chains, datasets |
| Thursday<br>9:00 - 10:30 | Visual Learning Architectures (C3) | Generative adversarial models<br>Coder decoders.<br>Siamese architectures<br>Spatial correlation<br>Introduction to Reinforcement Learning |
| Thursday<br>11:00 - 12:00 | Robotic perception and control (B) | Extension to 3D for Lie group EKF<br>Grasping control using learning.<br>Reinforcement Learning (example) |
| Friday<br>11:00 - 12:00 | Advanced topics (A3) | Non-perspective cameras (fisheye, panoramic), unified imaging model<br>Color vision<br>Color camera processing pipeline<br>New sensing technology: Event cameras/Plenoptic |

Assumed knowledge:

- Programming in Python
- Linear algebra: matrices, vectors