Lecture #1

Introduction

Who am I

Visit ANPL (also in person)

ANPL | Autonomous Navigation and Perception Lab

Who are You?

Introduction

- Autonomous mobile systems - **key questions include**
  - Where am I?
  - What is the surrounding environment?
  - What should I do next? Where am I going?
  - How to get there?

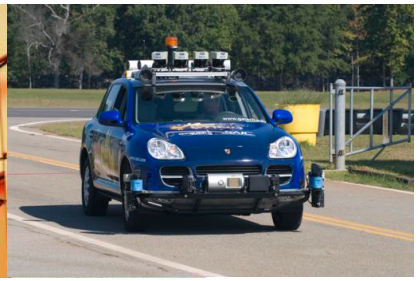
State Estimation & Perception

Planning & Control

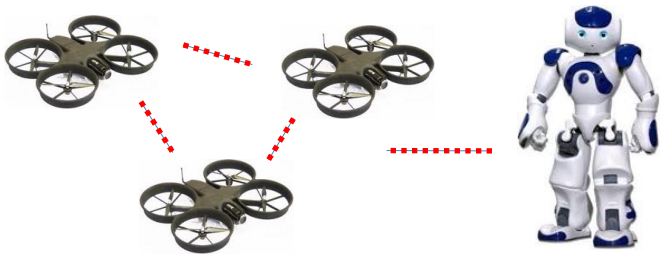
- Required online
- Additional complexity for multiple platforms/robots

Urban
IROS 2013 workshop

Indoor
Upenn



Autonomous Cars
Georgia Tech



Introduction

- Autonomous mobile systems - **key questions include**
  - Where am I?
  - What is the surrounding environment?
  - What should I do next? Where am I going?
  - How to get there?

State Estimation & Perception

Planning & Control

- Required capabilities:
  - Estimate robot pose wrt to the environment
  - Obtain a model of the environment
    - A given map (Uncertainties? Dynamic environments?)
    - Perceive and analyze the environment on the fly
  - Plan actions, taking uncertainty into account

Numerous Applications

- Indoor, urban, underwater navigation
- Space, other planets
- Autonomous driving
- Robotic surgery
- Multi-robot, swarms
- Visual odometry
- Virtual/augmented reality
- …

Vision Aided Quadrotor Navigation

Project Tango (Google)

Vision Aided Quadrotor Navigation

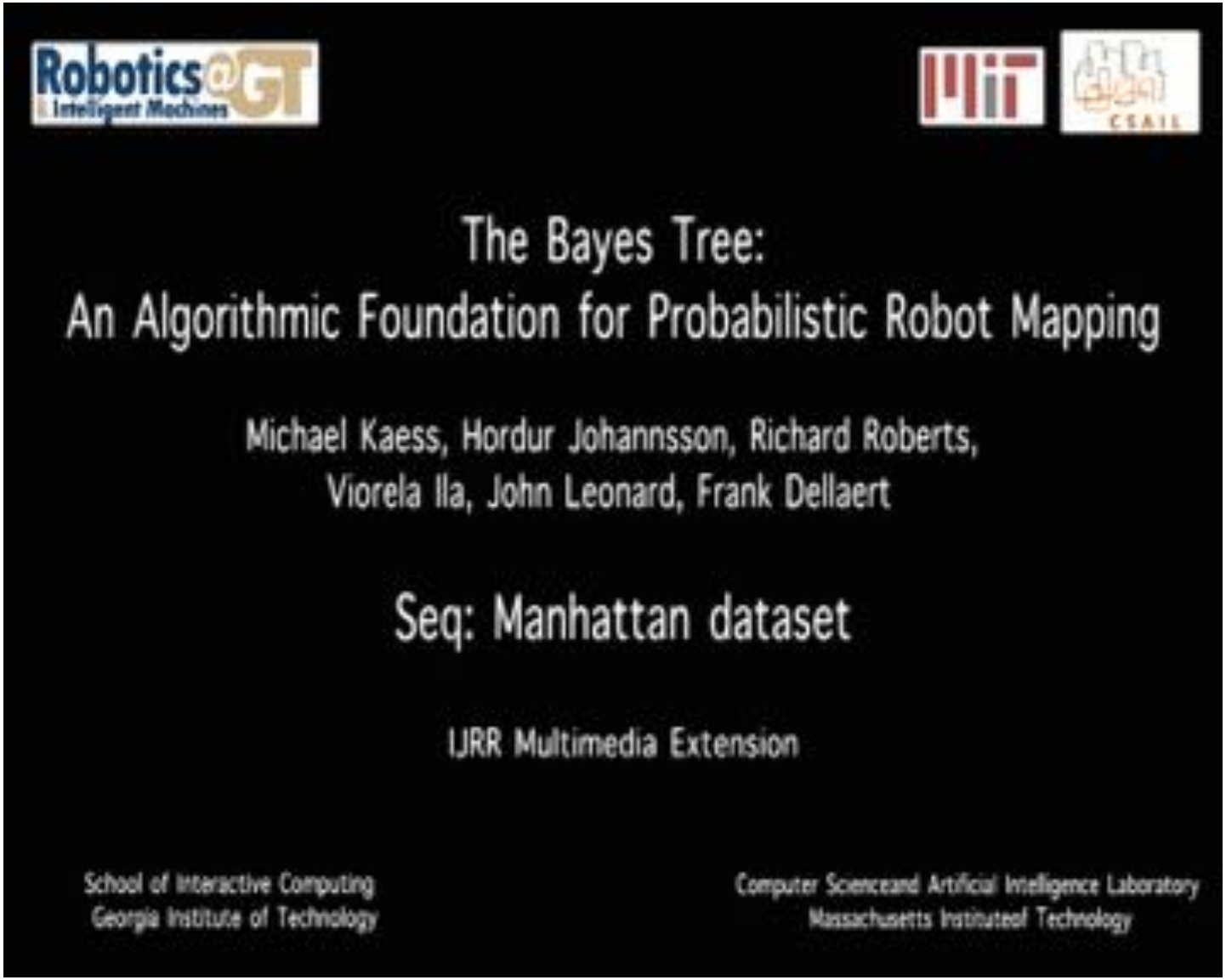
Aggressive Flight

Multi-Robot Localization, Mapping & Data Association

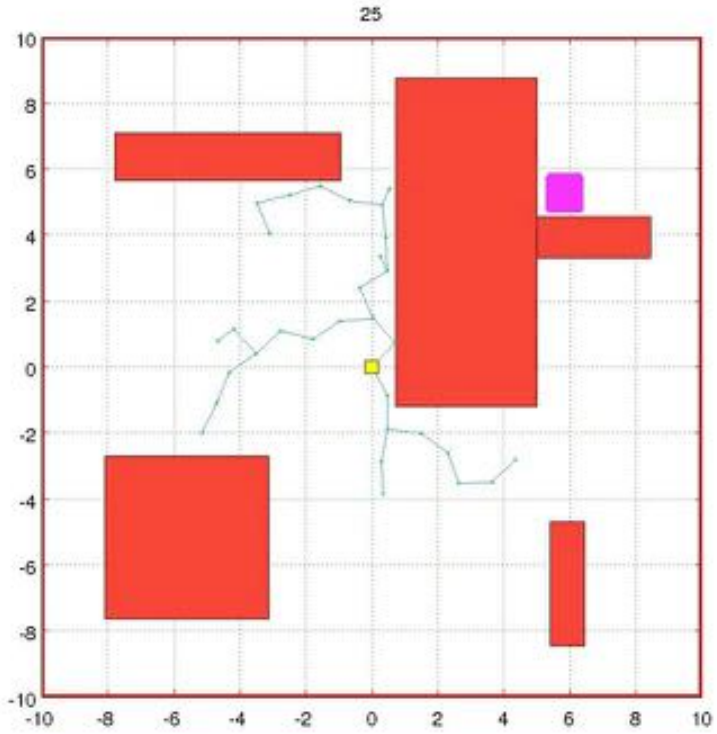
Structure From Motion (SfM): Building Rome in a Day

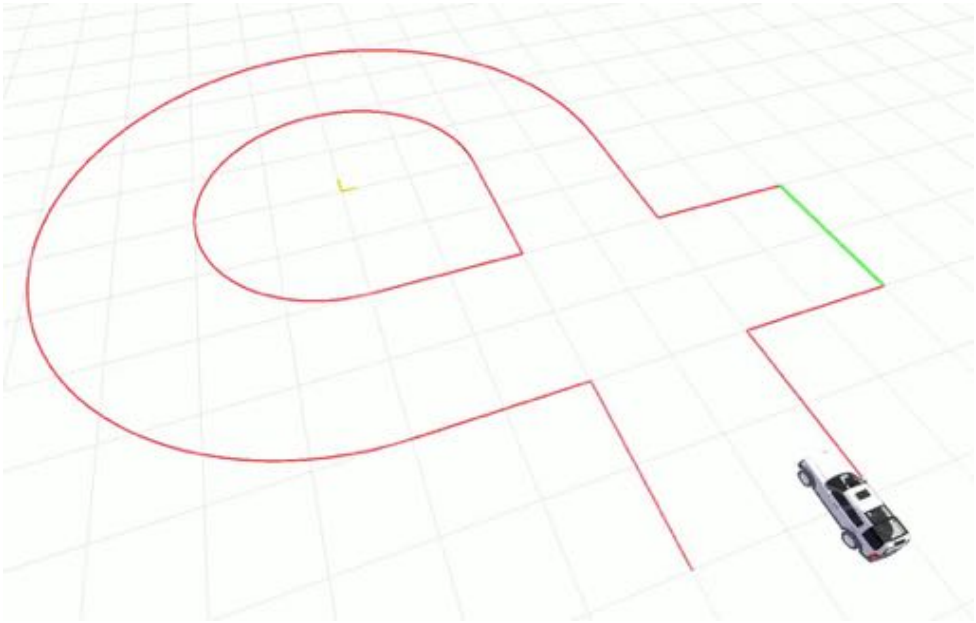
From http://www.cs.cornell.edu/~snavely/bundler/

Online Inference: The Bayes Tree

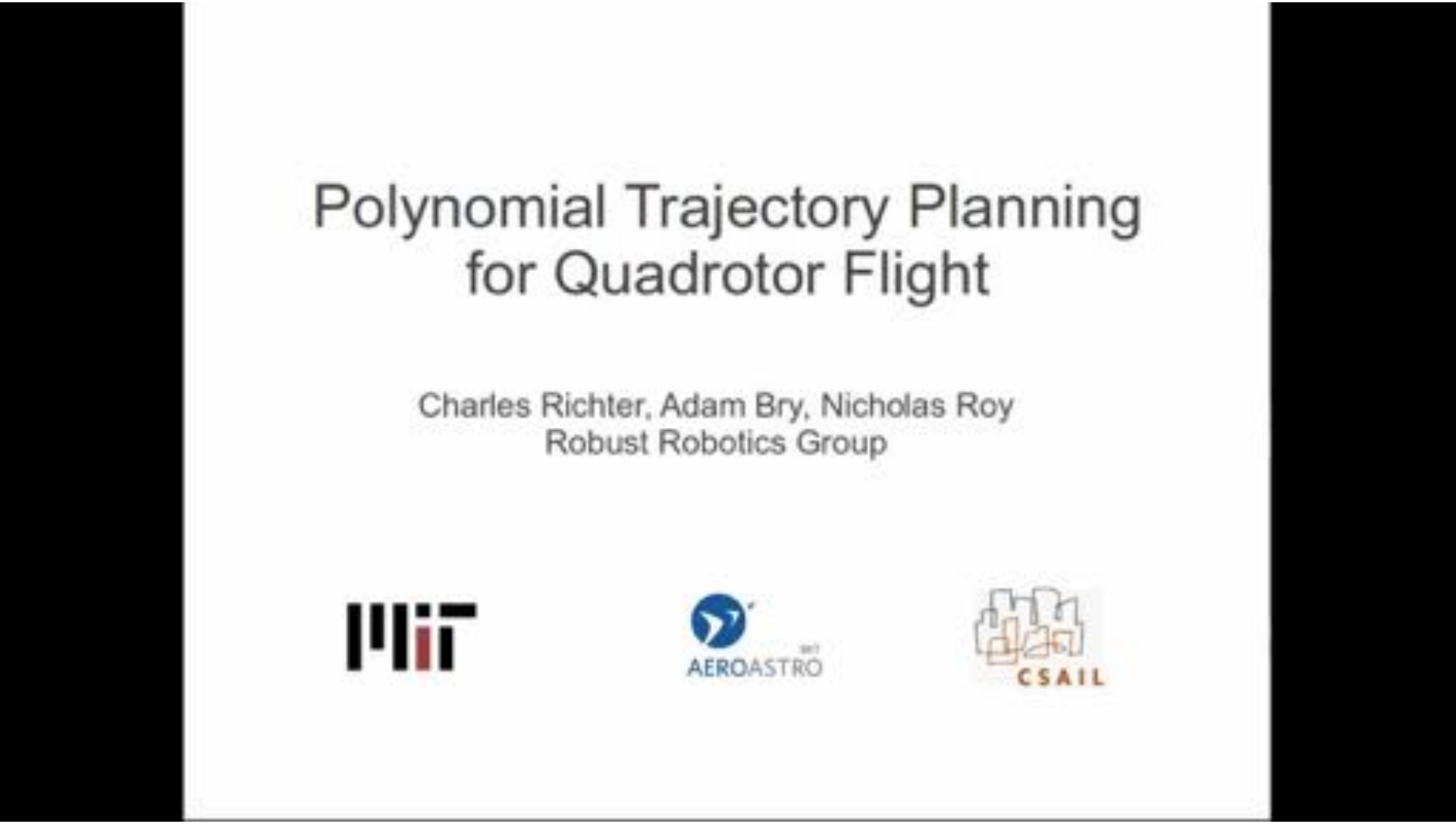


Sampling Based Motion Planning





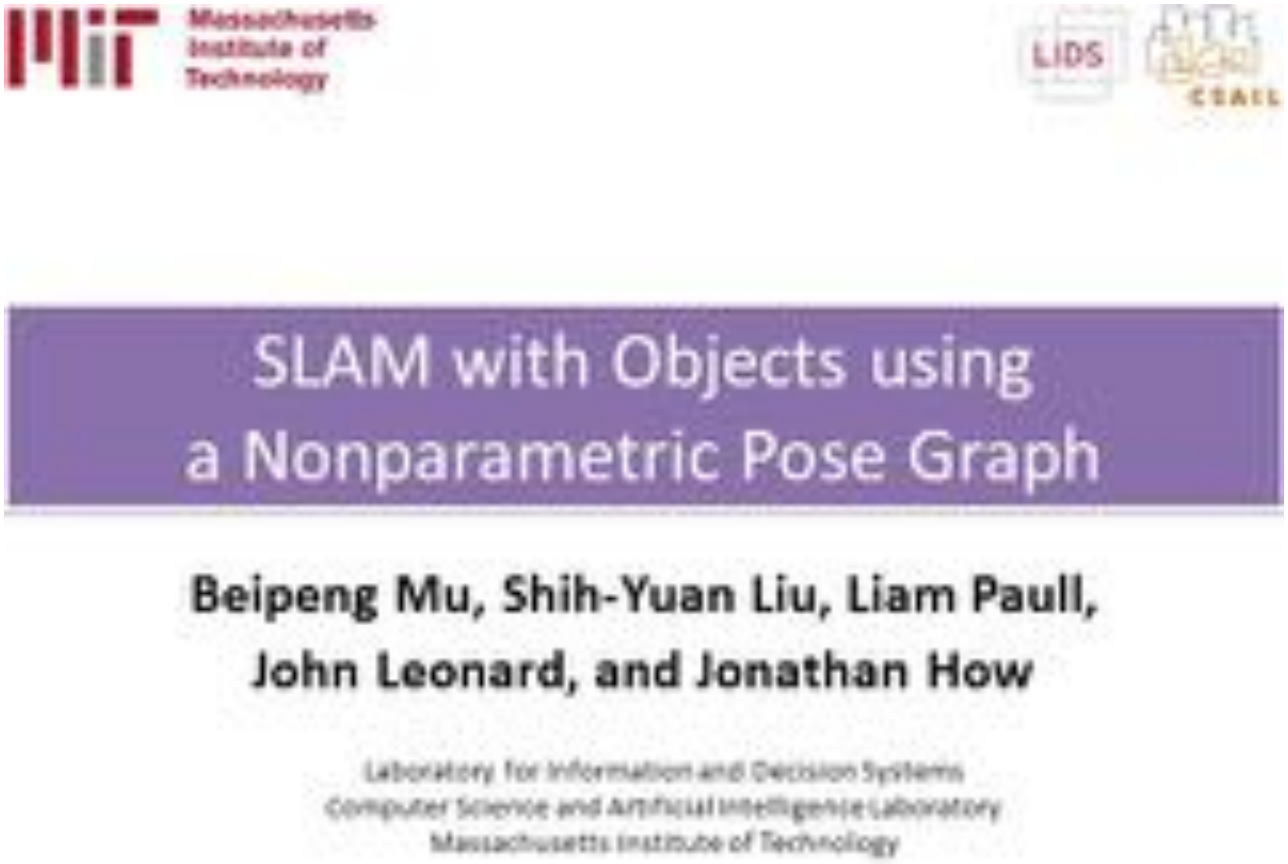
Application to Quadrotor Trajectory Planning



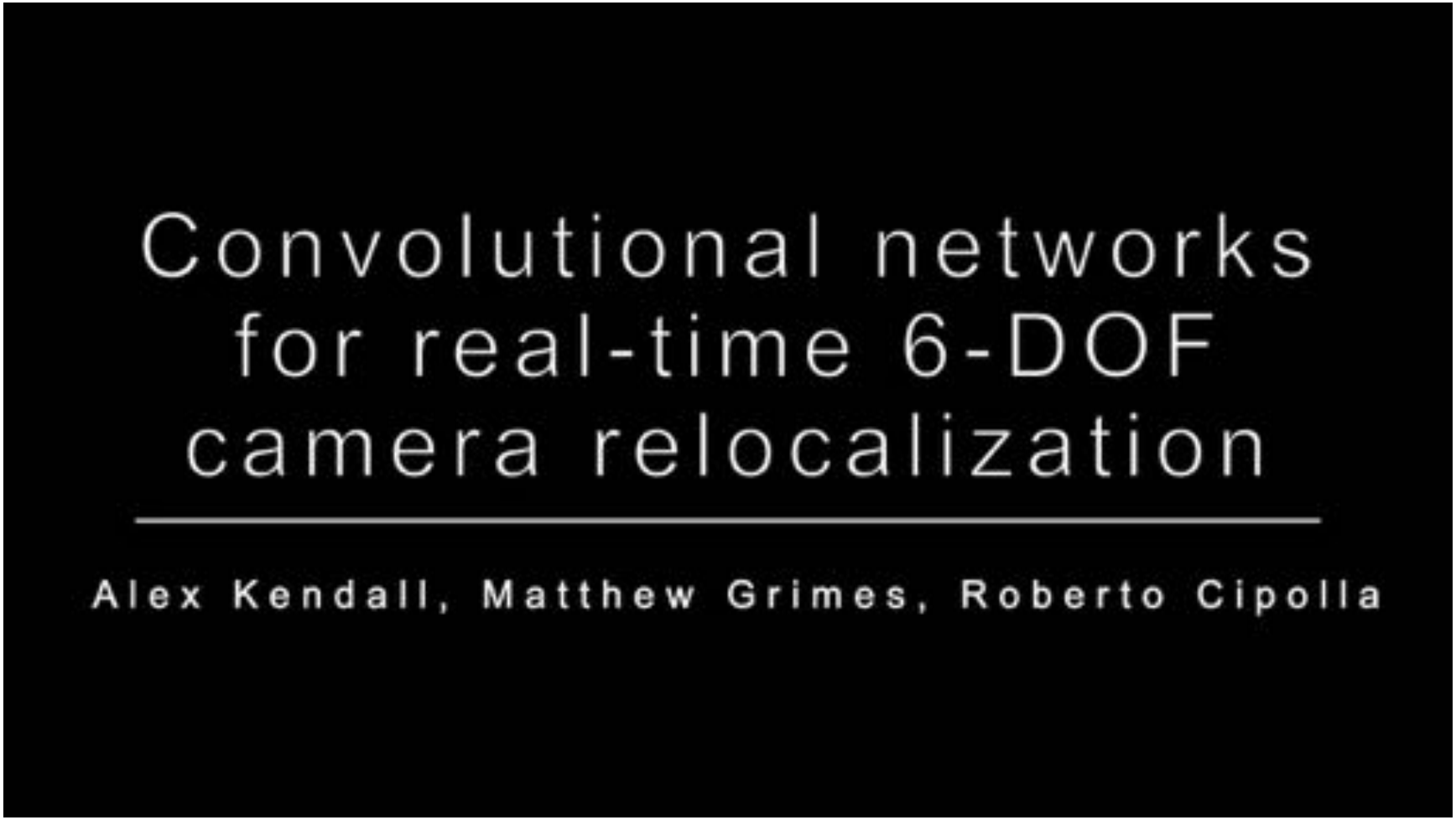
Augmented & Virtual Reality

Microsoft HoloLens (for example):

Nonparametric Object SLAM



Convolutional Neural Networks for Pose Estimation



Socially Aware Motion Planning with Deep Reinforcement Learning

Many More Applications

- Space, other planets
- Autonomous driving
- Robotic surgery
- Multi-robot, swarms
- Visual odometry
- …

This Course

- **Fundamental topics** in Vision Aided Navigation (VAN) and Simultaneous Localization and Mapping (SLAM)
- Some **advanced topics** towards end of course
- **Projects** focus on specific topic from a list – opportunity to get in-depth understanding, identify research problem
- A bit of **hands-on** experience (homework)

Course Diagram

3D Transformations | Dead Reckoning | Basic Probability

Bayesian Inference | Extended Kalman/Information Filter

Projective camera geometry | Multi View Geometry | Feature Matching

Bundle Adjustment | VAN, SLAM | Graphical models

Incremental Smoothing and Mapping (iSAM)

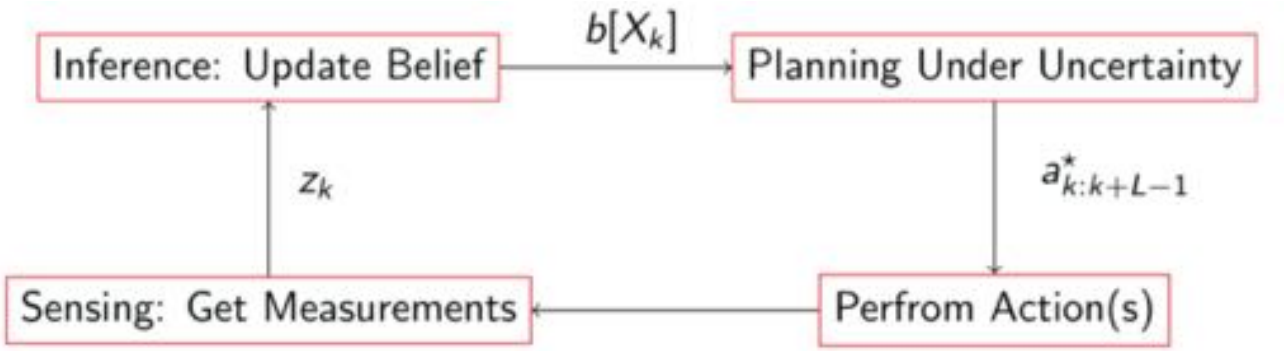
Advanced topics (subject to progress in class)

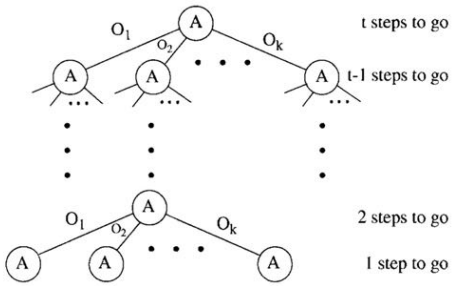
Multi-Robot SLAM & VAN | Belief Space Planning

Heads Up!

- In Spring'21 semester:

Autonomous Navigation and Perception (086762)





Heads Up!

- Technion Robotics Seminars (TRS) – Fall'21 semester:

TASP | TECHNION AUTONOMOUS SYSTEMS PROGRAM

We are delighted to introduce the upcoming series of lectures for Fall'21 semester:
Technion Robotics Seminars

Wednesdays at 15:00

03/11: Michael Kaess – Robotics Institute, Carnegie Melon University
10/11: Jan Faigl - Artificial Intelligence Center, Czech Technical University in Prague
17/11: Ilana Nisky - Biomedical Engineering, Ben Gurion University of the Negev
24/11 (at 16:00): Oren Salzman – Computer Science, Technion-Israel Institute of Technology
08/12: Tal Nir - Principal computer vision engineer, Asensus surgical
22/12: Luca Carlone - Laboratory for Information & Decision Systems (LIDS), Massachusetts Institute of Technology
05/01: Sarah Keren – Computer Science, Technion-Israel Institute of Technology
12/01: Shai Revzen - Electrical Engineering and Computer Science, University of Michigan
19/01: Sven Konig - Computer Science, University of Southern California
26/01: Hadas Kress-Gazit - Mechanical and Aerospace Engineering, Cornell University

Addition details: https://robotics-seminars.net.technion.ac.il/

Logistics

- Lectures: 3 weekly hours
- Grading policy:
  - Homework: 20% (teams of two students)
  - Project: 30%
  - Midterm exam: 50% (must pass)
    Moed A: 28/12/2021; Moed B: 03/02/2022
- Project
  - Choose topic from a list (1-3 papers)
  - Presentation to class
  - Report: summarize main ideas, identify weak points, basic implementation/demo
  - Teams of two students

Logistics

- Course webpage:
  - http://vindelman.net.technion.ac.il/teaching/
  - **Piazza**: https://piazza.com/technion.ac.il/fall2021/086761

- **Important**:
  - Course is maintained via Piazza
  - Provides: Handouts, homework, announcements, project and forum
  - **Sign up today** to the course Piazza page
  - **Let me know** (by email) in case you do not have a Technion email
  - **Choose project topic** November 23rd 2021 – no extensions!