Master in
Computer Vision
Barcelona

Project
Module 4
Coordination

Video Surveillance for Road Traffic Monitoring

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Project Goal

- **Main goal**
  - To learn the basic concepts and techniques related to video sequences mainly for surveillance applications
- **Scope**
  - Use of statistical models to estimate the background information of the video sequence
  - Use of connected component analysis to segment the foreground
  - Use optical flow estimations and compensations
  - Analyze system performance evaluation
- **Applicability**
  - Any problem where video sequence analysis can be applied to obtain accurate automatic results

Project Flowchart

- Stages:
  - Background estimation
    - Model background using statistical models
  - Foreground segmentation
    - Background subtraction and filtering
  - Video stabilization
    - Optical flow estimation & compensation to remove jittering
  - Region tracking
    - Uniquely identify objects of the scene and follow their movement
    - Count cars & measure speed

Methodology

- Students divided into groups of 4 people
- Semester is divided into 5 weeks
- Every week students submit their homework (code + slides)
  - Present their results in class
  - Answer questions
  - Intra group evaluation
- One hour class
  - ~30min devoted to discussions
  - ~30min to present next week's work

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Timetable

Academic Year 2015-2016							
week	date	time	lecture	lecturer	university	building	room
1	Thu. Dec. 10th	16:00 - 18:00	Introduction to video analysis and tracking. Motion segmentation	Montse Pardàs	UPC	D5	Merit 010
1	Thu. Dec. 10th	18:00 - 19:00	Project Introduction	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010
2	Tue. Dec. 15th	16:00 -18:00	Motion segmentation. Background subtraction	Montse Pardàs	UPC	D5	Merit 010
2	Thu. Dec. 17th	16:00 -18:00	Motion estimation. Optical flow	Verónica Vilaplana	UPC	D5	Merit 010
2	Thu. Dec. 17th	18:00 - 19:00	Project follow-up	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010
			Christmas Holidays (from 21st December to 6th January)				
3	Thu. Jan. 7th	16:00 - 18:00	Bayesian tracking (I)	David Varas	UPC	D5	Merit 010
3	Thu. Jan. 7th	18:00 - 19:00	Project follow-up	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010
4	Tue. Jan. 12th	16:00 -18:00	Bayesian tracking (II)	David Varas	UPC	D5	Merit 010
4	Thu. Jan. 14th	16:00 -18:00	Tracking with active shapes	Constantine Butakoff	UPC	D5	Merit 010
4	Thu. Jan. 14th	18:00 - 19:00	Project follow-up	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010
5	Tue. Jan. 19th	16:00 -18:00	Model-based tracking	Javier Ruiz	UPC	D5	Merit 010
5	Thu. Jan. 21st	16:00 -18:00	Gesture and action recognition	Josep Ramon Casas	UPC	D5	Merit 010
5	Thu. Jan. 21st	18:00 - 19:00	Project follow-up	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010
			Gesture and action recognition				
6	Tue. Jan. 26th	16:00 -18:00	Behaviour understanding in videos	Jordi Gonzalez	UPC	D5	Merit 010
6	Thu. Jan. 28th	16:00 -18:00	Applications	Xavier Giró / Ferran Marqués	UPC	D5	Merit 010
6	Thu. Jan. 28th	18:00 - 19:00	Project follow-up	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010
7	Tue. Feb. 2nd		HOMEWORK				
7	Thu. Feb. 4th	16:00 -19:00	Project presentations	Javier Ruiz / Xavier Giró	UPC	D5	Merit 010

← Week 1: 10th December

← Week 2: 17th December

← Week 3: 7th January

← Week 4: 14th January

← Week 5: 21st January

← Week 6: 29th January

← Final presentations and Report: 4th February

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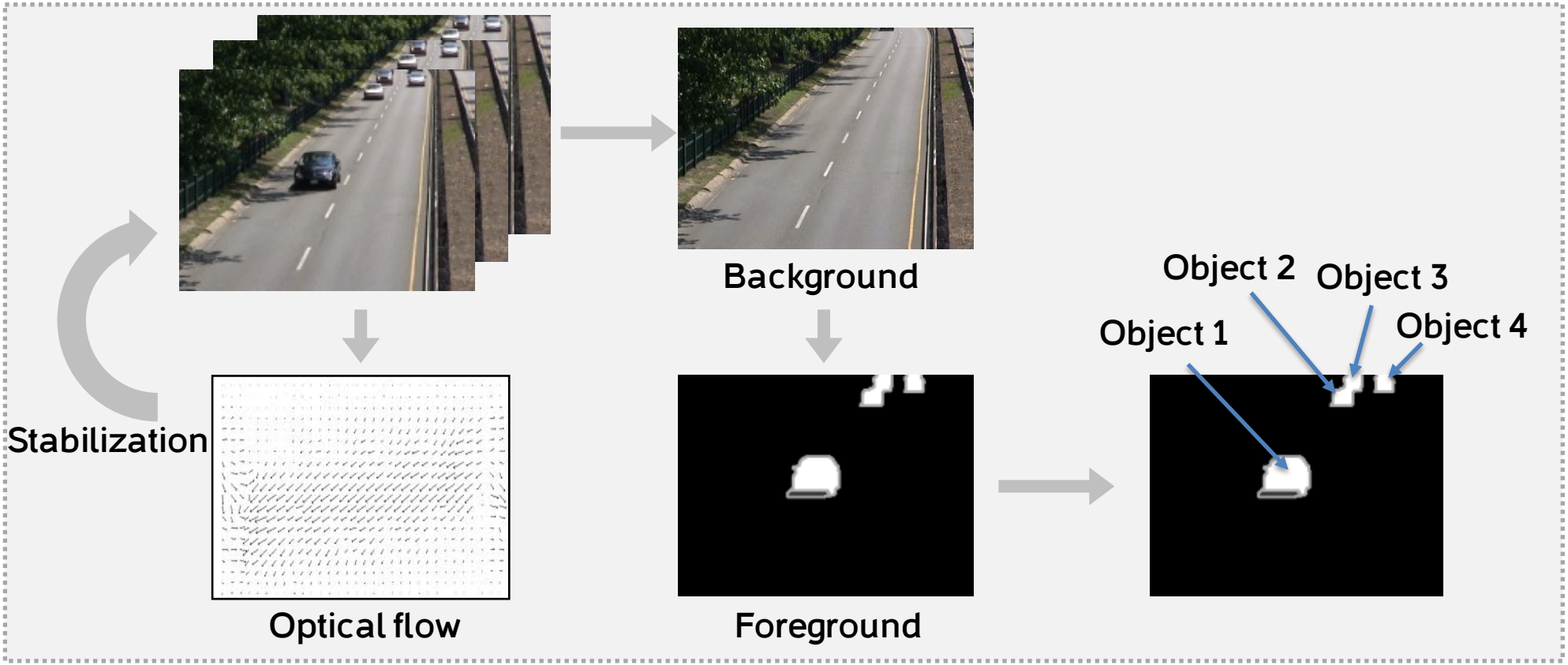
Project Schedule



Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
•Introduction •DB •Evaluation metrics	•Background estimation •Stauffer & Grimson	•Foreground segmentation •Area filter •Hole filling •Shadow removal	•Optical flow •Video stabilization	•Region tracking •Kalman filter	•Presentation

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Learning Goals

Skills	Week
Statistical models *Gaussian, S&G*	2
Connected Component Analysis *Area filter, hole filling*	2
Optical flow *Lucas–Kanade*	3
	4
Object tracking *Kalman filter*	5
Classification performance evaluation	1-5

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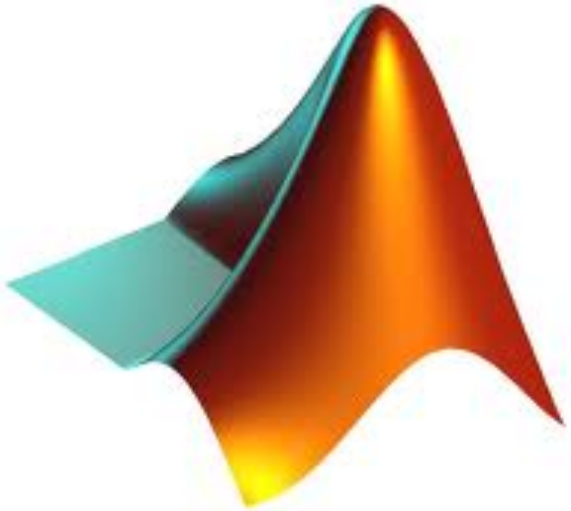
Programming Language

- Matlab (http://mathworks.es)
  - Required toolboxes
    - Image processing
  - Additional toolboxes
    - Computer vision



- OpenCV (http://mathworks.es)
  - Python, C++ interfaces

Virtual machine

- X2go, download client from x2go page:http://wiki.x2go.org/doku.php/start
- Configure as:
  - **host:** 147.83.91.181
  - **login:** ihcv$X ($X is the group number as 01, 02, …)
  - **password:** ihcv
  - **SSH port:** 2241
  - **Session type:** GNOME

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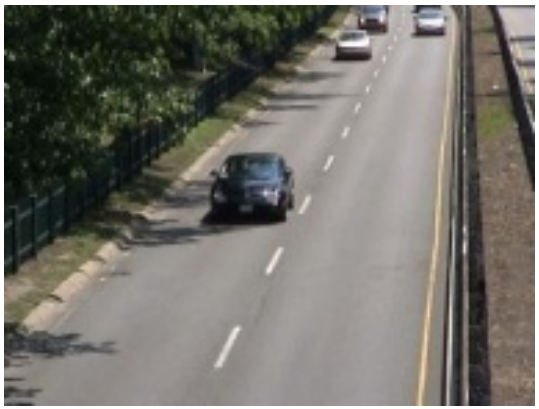
Datasets

- ChangeDetection Video Database
  - http://www.changedetection.net
  - 11 video categories: 4-6 videos in each
    - Baseline, dynamic background, jitter, shadow, etc.
  - Ground truth images
    - Static, shadow, outside ROI, motion, unknown



Datasets

- KITTI Vision Benchmark Suite
  - http://www.cvlibs.net/datasets/kitti
  - Optical flow ground truth

  - TRAINING DATASET
    - 194 image **pairs** + optical flow ground truth
  - TEST DATASET (subset)
    - 195 image **pairs** + optical flow ground truth

Project Evaluation

- The Project Development: PD
  - Weeks 1-4 (PD_i)
    - Delivered code + short presentation.
    - Completion of tasks and optionals
    - Feedback and questions to professors in class
  - Week 5 (PD_5)
    - Full code + short report
- Intra-Group Evaluation:
  - Every week students quantize the % of workload done by each member of the team
- Final project presentation: PP

$$PP = 0.5 \cdot PP^{professor} + 0.5 \cdot PP^{students}$$

- The final mark is

$$V = \sum_{i=1}^{4} 0.15 \cdot PD_i + 0.3 \cdot PD_5 + 0.1 \cdot PP$$

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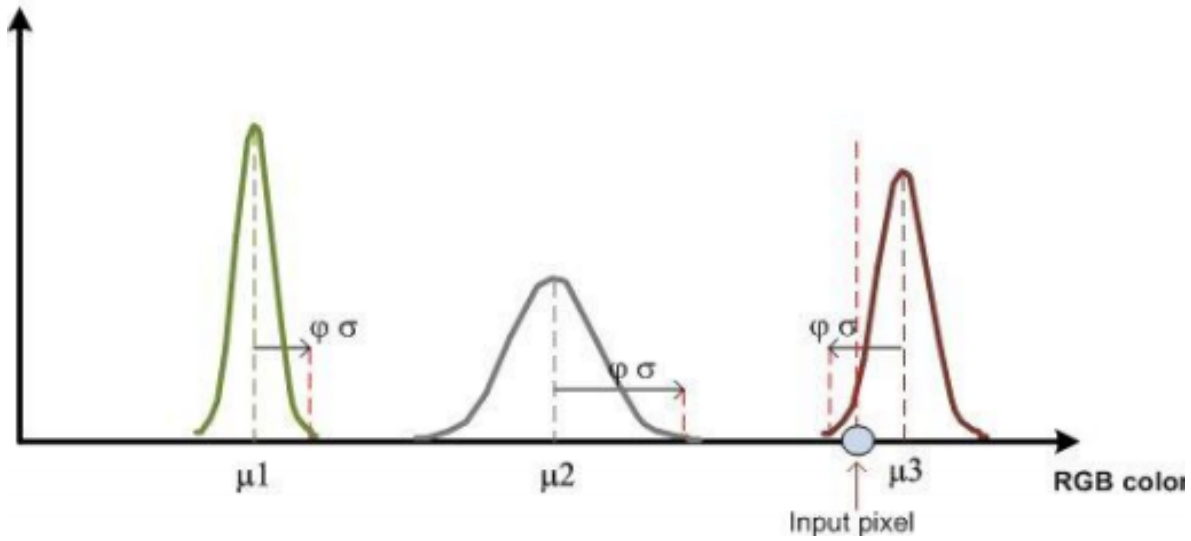
Assignments: Week 1

- Introduction to video sequence analysis and evaluation
  - Understand and familiarize with the programing framework used in the project
  - Learn about the databases to be used
  - Practice the evaluation metrics
  - Read / write video sequences

Assignments: Week 2

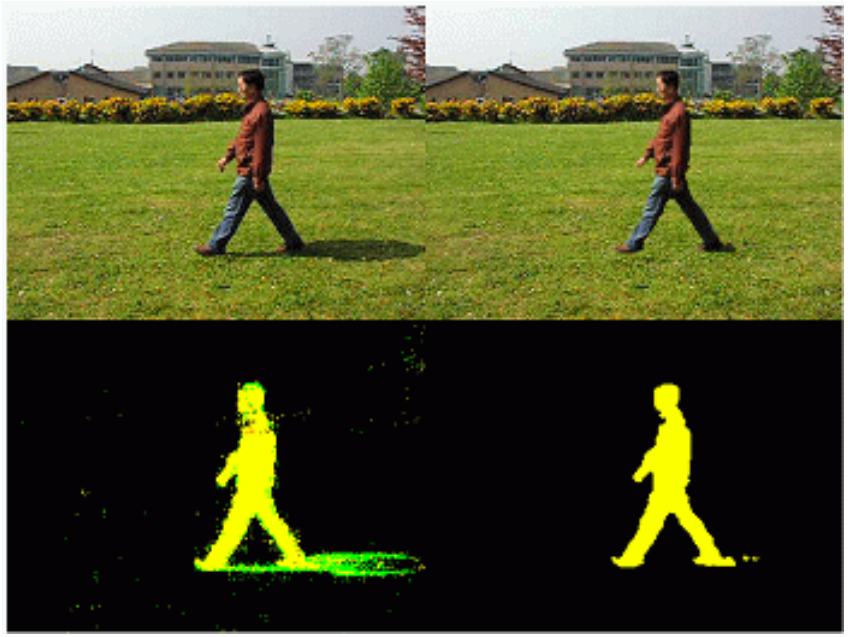
- Background estimation
  - Model the background pixels of a video sequence using a simple statistical model to classify the background / foreground
    - Single Gaussian per pixel
    - Adaptive / Non-adaptive

    The statistical model will be used to preliminary classify foreground
  - Comparison with more complex models (Stauffer and Grimson)



Assignments: Week 3

- Foreground segmentation
  - Implement a robust foreground segmentation algorithm.
  - The statistical model implemented in the previous week will be used to classify foreground pixels in the video.
  - Refine the result with component analysis filtering
  - Shadow removal system



Assignments: Week 4

- Video stabilization
  - Removed un-wanted camera jitering
  - Motion Estimation by computing optical flow
  - Optical flow must be used to compensate the camera jitering and create a new stabilized video

Assignments: Week 5

- Region tracking
  - Implement a tracking system to uniquely identify the objects in the scene.
  - A Kalman filter will be used to predict object positions and to help assign unique labels to all objects.
  - Detect and track the cars from a provided video sequence, labeling each of them with a bounding box and a unique numerical identifier.
  - Estimate the speed of the cars appearing in the video sequence, adding this information to the ID.

Material

- **PROJECT DOCUMENTATION**
  - Describes all the information needed to perform and evaluate the project
  - Location: Virtual Campus UAB