

Erasmus Mundus Joint Master Degree (EMJMD) in
Image Processing and Computer Vision (IPCV)



Applied Video Sequence Analysis

Lab 1 “Foreground segmentation”

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- **To develop a basic foreground segmentation algorithm** to detect moving objects on a stationary background
- **To improve the performance** of the basic algorithm
- **To evaluate the performance of foreground segmentation** algorithms using standard measures and Matlab code
- **To write a report** to summarize achievements and results
 - Motivate the development of the different versions and modes (i.e., what does it enhance?)

- Assignment available on Moodle to submit your material
- The material must be submitted as a ZIP file with the following format *name1Surname1_name2Surname2_lab1.zip*
- The submitted ZIP file will contain
 - Report in PDF format (max 6 pages)
 - *Makefile* to compile and link the program by simply running *make**
(Suggestion: use the makefile provided for Lab0)
 - “src” directory with all source files (.h, .hpp, .c and .cpp) necessary for compiling and executing the corresponding program in Linux
 - “res” directory with the foreground masks for the *Baseline* category of CDNet2012 for different algorithms versions implemented.

*You may want to develop your C/C++ program using Eclipse but only the Makefile must be submitted (please do not submit Eclipse' config files)

- Task 0 – Void foreground segmentation using template
 1. Go to “LAB 1” on Moodle
 2. Download the example project “LAB 1 code template.zip”
 3. Download the datasets “AVSASlidesVideosdataset” and “ChangeDetection dataset 2012 (baseline category only)”
 4. Uncompress the files
 5. Create a new Project Lab1.0AVSA2020 in Eclipse (see next slide)
 6. Open the Lab1.0AVSA2020.cpp file in the “src” directory
 7. Set the directory of the dataset and results according to your installation
 8. Compile it (“Build Project” in Eclipse)
 9. Create a “Launch Configuration” for the Project
 - Select the Project in the “Project Explorer” tab, go to the toolbar and select in the “Launch Configuration”pane “Create New Launch Configuration”
 - In the “Environment” tab set
LD_LIBRARY_PATH=/opt/installation/OpenCV-3.4.4/lib
 10. Run it ...

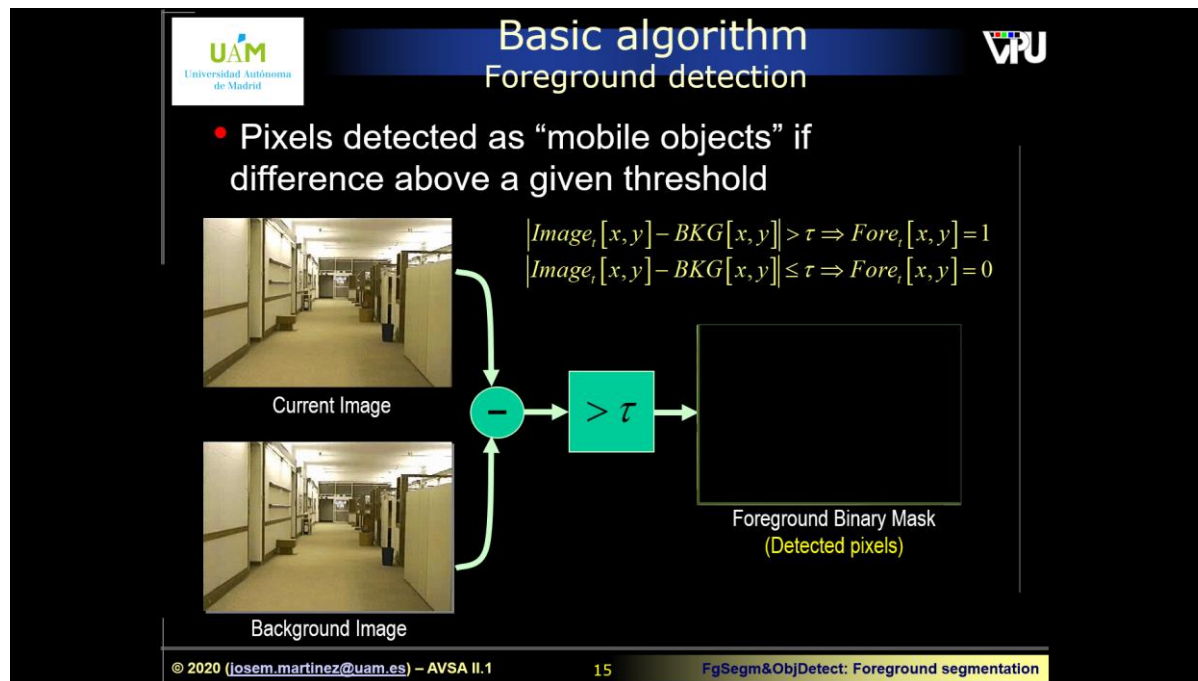
- Creating an Eclipse Project from scratch (see Lab0)
 - How to install and setup Eclipse for OpenCV 3.4.4
 - Configure Eclipse CDT for using OpenCV
- Creating an Eclipse Project with existing code
 - After creating the Projects and src folder ...
 - ... instead of creating a new source file (step 7), copy the files (.cpp, .hpp) into the src folder
 - Select them in a Files explorer and move them to the Project src folder in Eclipse
 - Continue with step 8
- ...

- ...
- Creating a copy of an Eclipse Project (for incremental development – e.g., different versions in Lab1)
 - Select source Project in “Project Explorer”: then “copy” and “paste”
 - Name the new project
 - Rename “main” file and change *project dependent* code (e.g., `project_name`)
 - Delete Binaries in Project Folders (e.g., Debug)
 - Build the Project
 - Create Launch Configuration for the new project (see Lab0)
 - Remember to set `LD_LIBRARY_PATH`
 - Run the Project

- Task 1 - Implementation of foreground segmentation algorithms using the OpenCV library

—Methods

- **Lab1.1.1: Generation of foreground segmentation mask for each video frame using “frame difference”**
 - Parameters: tau (double), rgb (true/false)




- Task 1 - Implementation of foreground segmentation algorithms using the OpenCV library

- Methods


- **Lab1.1.2: Progressive update of background model through selective running average (blind and selective update)**

- Parameters: tau (double), rgb (true/false), alpha (double), selective_update (true/false)
- *Recommendation: firstly implement blind mode*



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Background model update



- Progressive adaptation of background model:
 - Background image updated with part of current image for pixels not belonging to the foreground mask ➡ **selective running average**

$$BKG_{t+1}[x,y] = \alpha Image_t[x,y] + (1 - \alpha) BKG_t[x,y] \quad \longleftrightarrow \quad Fore_t[x,y] = 0$$

- Parameter α determines adaptation speed (e.g., $\alpha = 0.05$)

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FgSegm&ObjDetect: Foreground segmentation

- Task 1 - Implementation of foreground segmentation algorithms using the OpenCV library

- Methods


- **Lab1.1.3: Suppression of stationary objects that appear or are removed**

- Parameters: tau (double), rgb (true/false), alpha (double), threshold (int)



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Background model update



- Suppression of ghosts (2) - stationary objects that appear or are removed:
 - Counter per pixel
 - Counter incremented every time pixel is detected as foreground in current image
 - Counter reset every time pixel is detected as background in current image
 - Pixel “incorporated” to background model if counter reaches a threshold

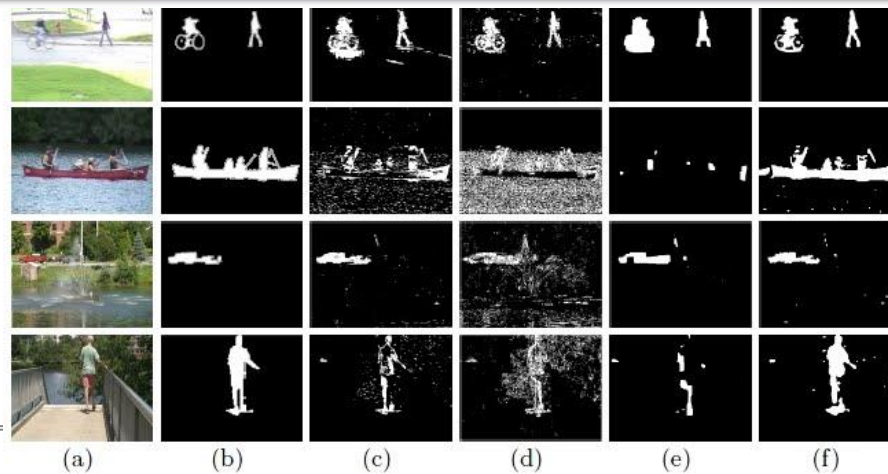
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FgSegm&ObjDetect: Foreground segmentation

- Task 1 - Implementation of foreground segmentation algorithms using the OpenCV library
 - Requirements
 - Only use three source files (main.cpp, fgseg.cpp and fgseg.hpp)
 - The algorithm operates over gray-level images and colour-images (optional)
 - Report comparative subjective results using the VideoSlidesAVSA dataset for the three versions
 - Report a sensitivity analysis of the parameters involved in algorithms (i.e. study the values of the parameters involved and their impact in the output or the foreground mask)
 - Recommendations
 - Develop firstly the gray-level versions
 - Motivate in the report the development of the different versions and modes (i.e., what does it enhance?)
 - Provide a subjective comparative among versions using the AVSASlidesVideo dataset


- Task 2 – Evaluate your algorithm using the ChangeDetection datasets (2012 version, CDNet2012)
 - Evaluate the algorithm developed in Task 1 using the Baseline category from <http://changedetection.net/>
 - Category of the dataset available in Moodle
 - MATLAB code is available for evaluating the results of your algorithms
 - In the report, include performance comparisons with selected approaches from <http://jacarini.dinf.usherbrooke.ca/results2012>



• Task 3.1 - Implementation of a shadow suppression module using the OpenCV library


—Method

- Suppression of shadows based on the chromaticity-based method


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Basic algorithm

Chromaticity-based method



- Shadow detection

$$Image_t[x, y] = (IH_t[x, y], IS_t[x, y], IV_t[x, y])$$

$$BKG_t[x, y] = (BH_t[x, y], BS_t[x, y], BV_t[x, y])$$

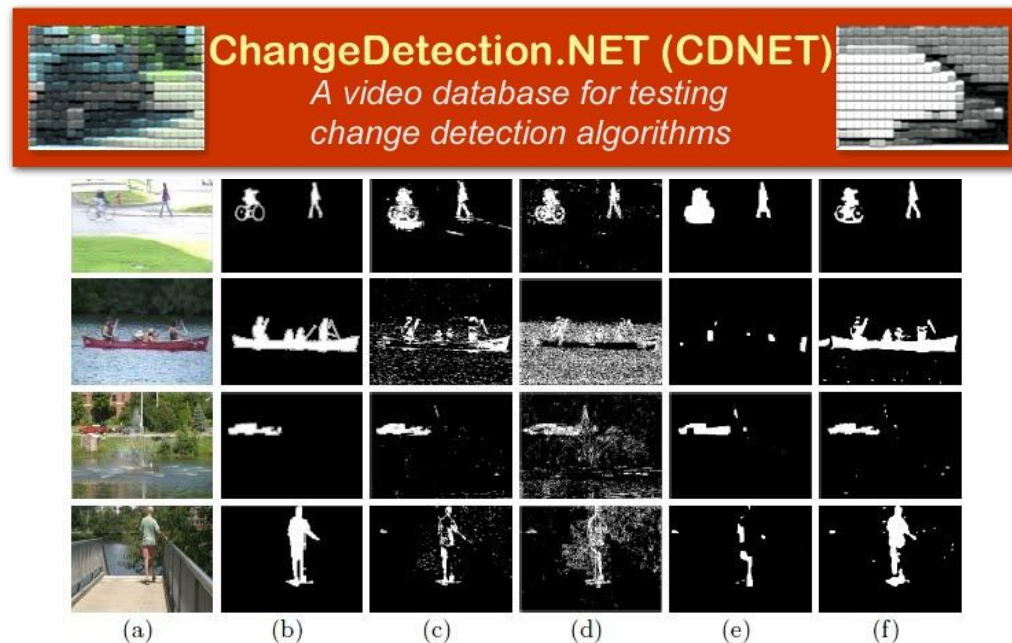
$$\alpha \leq \frac{IV_t[x, y]}{BV_t[x, y]} \leq \beta \wedge |IS_t[x, y] - BS_t[x, y]| \leq \tau_S \wedge D_H \leq \tau_H \Rightarrow Shadow_t[x, y] = 1$$

$$D_H = \min(|IH_t[x, y] - BH_t[x, y]|, 360 - |IH_t[x, y] - BH_t[x, y]|)$$

(e.g., $\alpha = 0.5, \beta = 0.9$)
- Thresholds determined empirically

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FgSegm&ObjDetect: Shadow detection


- Task 3.2 – Evaluate the suppression of shadows method
 - Evaluation of new algorithm using the *Shadow* category from <http://changedetection.net/>



• Task 4.1 – Implementation of advanced background subtraction algorithms

– Method


▪ Single Gaussian



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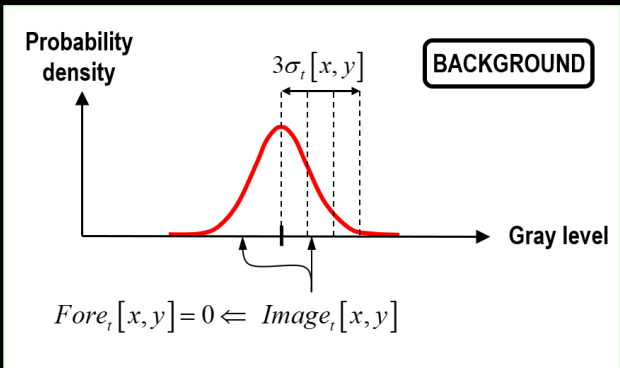
Robust background models

Parametric models



VPU

- Unimodal model (Gaussians)
 - Background model (Gaussian distribution for each pixel) ➡ Mean and standard deviation per pixel $\mu_t[x, y], \sigma_t[x, y]$

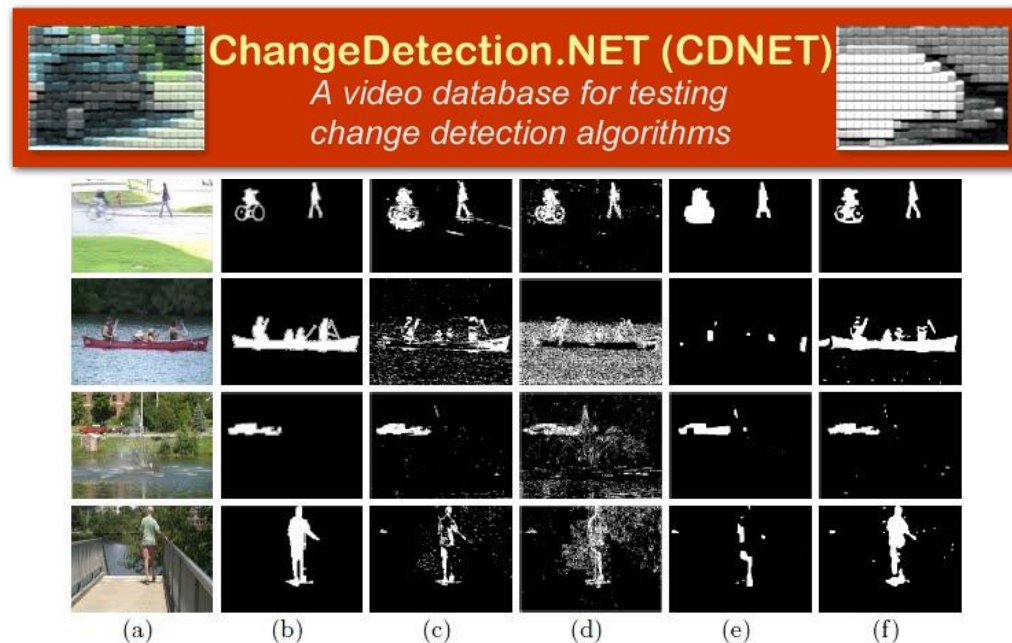


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FgSegm&ObjDetect: Foreground segmentation

- Task 4.2 – Evaluation of advanced background subtraction algorithm
 - Evaluation of the new algorithm using the *Dynamic Background* category from <http://changedetection.net/>




- Task 5.1 – Implementation of advanced background subtraction algorithms
 - Method
 - GMM
 - Recommendation
 - Implement firstly a version using only a Single Gaussian



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Robust background models

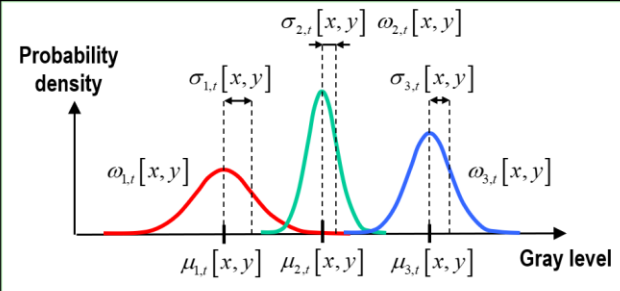
Parametric models



VPU

- Multimodal model (Mixture of Gaussians)
 - Background model (K Gaussian distributions per pixel; K between 3 and 5) → Mean, deviation and weight per Gaussian

$$\mu_{i,t}[x, y], \sigma_{i,t}[x, y], \omega_{i,t}[x, y]$$



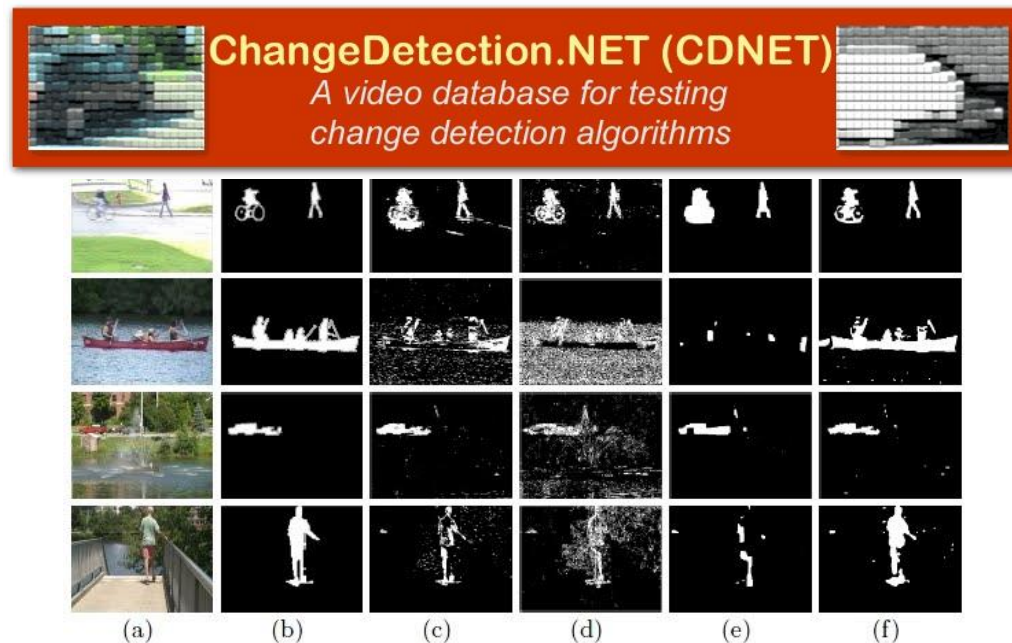
The graph illustrates a multimodal background model using a mixture of Gaussians. The x-axis represents the 'Gray level' and the y-axis represents the 'Probability density'. Three Gaussian distributions are shown, each with a different color (red, green, and blue). The red distribution has mean $\mu_{1,t}[x, y]$, standard deviation $\sigma_{1,t}[x, y]$, and weight $\omega_{1,t}[x, y]$. The green distribution has mean $\mu_{2,t}[x, y]$, standard deviation $\sigma_{2,t}[x, y]$, and weight $\omega_{2,t}[x, y]$. The blue distribution has mean $\mu_{3,t}[x, y]$, standard deviation $\sigma_{3,t}[x, y]$, and weight $\omega_{3,t}[x, y]$. The total probability density is the sum of these three individual densities.

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FgSegm&ObjDetect: Foreground segmentation

- Task 5.2 – Evaluation of advanced background subtraction algorithm
 - Evaluation of the new algorithm using the *Dynamic Background* category from <http://changedetection.net/>

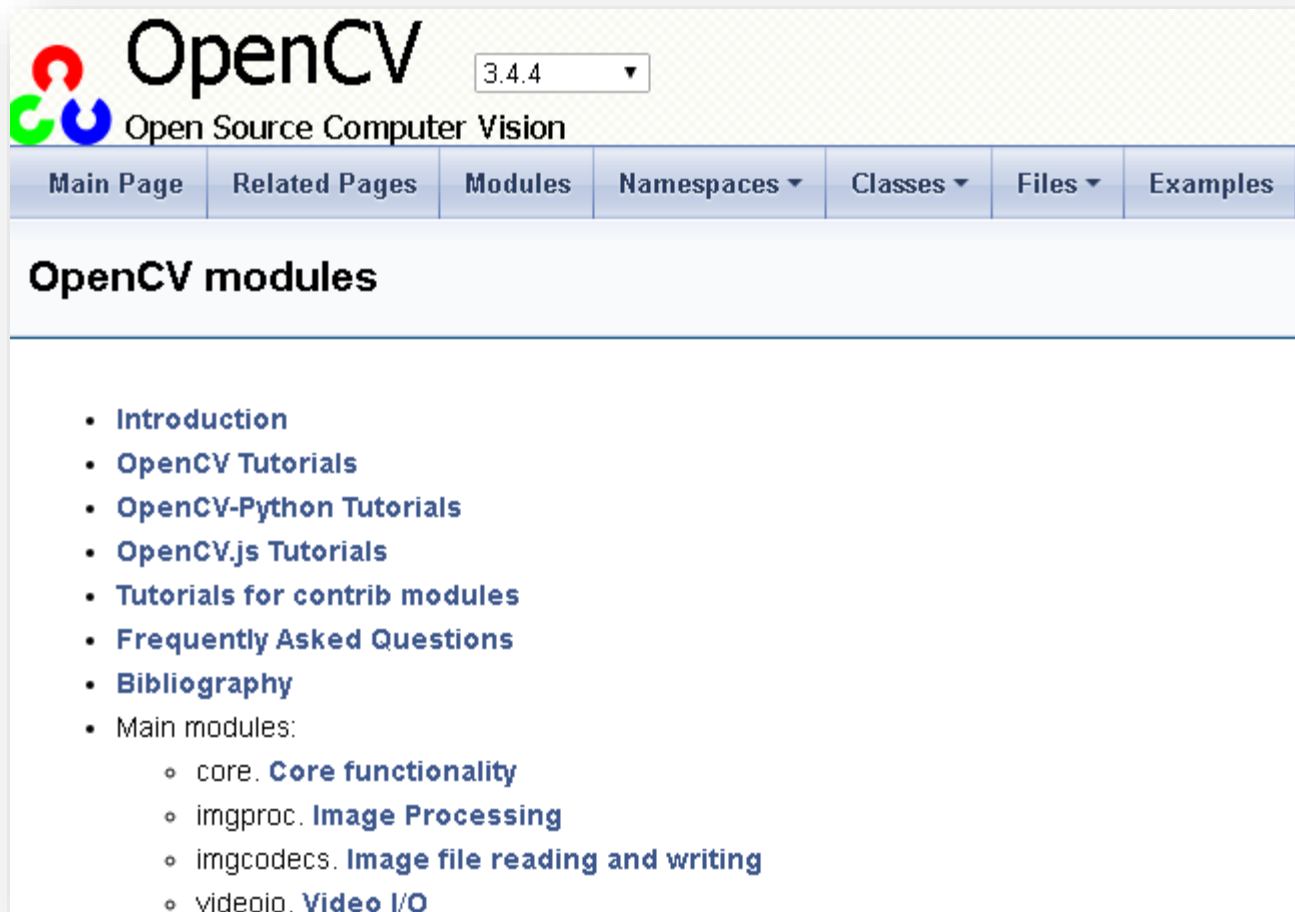


- This lab assignment will be **graded with 10 points**
 - Report (up to 2 points) – Please follow the report format (see *Moodle*)
 - Task 1 (up to 2 points)
 - Task 2 (up to 2 points)
 - Task 3 (up to 1 points)
 - Task 4 (up to 1 points)
 - Task 5 (up to 2 points)

- The following general criteria will be used for grading:
 - The solution addresses the requirements for the assignment.
 - The program compiles, links, and executes.
 - The program runs correctly.
 - The program is easy to read and to understand, i.e., it is well commented, and variables are correctly named.
 - The lab report clearly describes the algorithm and experiments.
- The following specific criteria will be used for grading:
 - Foreground segmentation using colour information.
 - Complexity of the implemented algorithms
 - Processing with OpenCV functions at matrix/vector level instead of pixel-level.

In addition, up to an extra point (1 point) may be awarded depending on the quality of the software delivered in the assignment.

- Check OpenCV documentation for finding specific functions at <https://docs.opencv.org/3.4.4/>



The screenshot shows the OpenCV 3.4.4 documentation website. At the top, there is the OpenCV logo (three interlocking circles in red, green, and blue) followed by the text "OpenCV" and "Open Source Computer Vision". A dropdown menu shows "3.4.4". Below this is a navigation bar with tabs: "Main Page", "Related Pages", "Modules", "Namespaces", "Classes", "Files", and "Examples". The "Modules" tab is selected. The main content area is titled "OpenCV modules" and contains a list of links: "Introduction", "OpenCV Tutorials", "OpenCV-Python Tutorials", "OpenCV.js Tutorials", "Tutorials for contrib modules", "Frequently Asked Questions", "Bibliography", and "Main modules:". Under "Main modules:", there are sub-links: "core. Core functionality", "imgproc. Image Processing", "imgcodecs. Image file reading and writing", and "videoio. Video I/O".