University of Lincoln Assessment Framework
Assessment Briefing 2023-2024

Module Code & Title: CMP9135M Computer Vision
Contribution to Final Module Mark: 100%

Description of Assessment Task and Purpose:

Requirements:

This assessment is an **individual** assignment and comprises three assessed tasks, as detailed below.

1. Image segmentation and detection. Weight: 40% of this component
2. Feature calculation. Weight: 30% of this component
3. Object tracking. Weight: 30% of this component

Task 1: Image Segmentation and Detection

Download two files: 'ball_frames.zip' from Blackboard. Unzip the dataset file, you should obtain a set of 126 images. Among those images, there are 63 ball colour images and 63 corresponding ball mask images (ground-truth segmentation). Figure 1 shows an example of one ball image and its corresponding mask image.

Please use conventional computer vision techniques (no deep/machine learning solution allowed in this task) to implement the following tasks. Please note that you are expected to develop one model with same parameter settings for all the images.

Task a): Automated ball objects segmentation. For each image, automatically segment the balls from background.

Task b): Segmentation evaluation. For each ball image, calculate the Dice Similarity Score (DS) which is defined in Equation 1; where M is the segmented ball region you obtained from Task 1, and S is the corresponding ground-truth binary ball mask. Please note that, in this case, for the provided ball mask images, you can convert the grayscale images into binary images (e.g. ball object and background), and use the converted binary images as ground-truth mask.

$$DS = \frac{2|M \cap S|}{|M|+|S|} \quad (1)$$

The calculated DS shall be between 0 and 1. For example, DS is 1 if your segmentation matches perfectly with the ground-truth mask, whist DS is 0 if there is no overlap between your segmentation and ground-truth mask.

(a) Balls image

(b) Balls mask image (Ground Truth)

Figure 1

Your report should include: 1) for all the 63 ball images, please provide a bar graph with x-axis representing the number of the image, and y-axis representing the corresponding DS. 2) calculate the mean and standard deviation of the DS for all the 63 images, and 3) briefly describe and justify the implementation steps. Please note that you are required to show the best 5 and worst 5 segmented ball images (along with the corresponding ball GT mask images) in the Appendix.

Task 2: Feature Calculation

This part of the assignment will deal with feature extraction, more specifically you will be examining texture and shape features. Using the provided GT ball masks to obtain the corresponding ball patches from original RGB images, carrying out the following tasks.

a) (shape features) For each of the ball patches, calculate four different shape features discussed in the lectures (solidity, non-compactness, circularity, eccentricity). Plot the distribution of all the four features, per ball type.

b) (texture features) Calculate the normalised grey-level co-occurrence matrix in four orientations (0°, 45°, 90°, 135°) for the patches from the three balls, separately for each of the colour channels (red, green, blue). For each orientation, calculate the first three features proposed by Haralick et al. (Angular Second Moment, Contrast, Correlation), and produce per-patch features by calculating the feature average and range across the 4 orientations. Select one feature from each of the colour channels and plot the distribution per ball type.

c) (discriminative information) Based on your visualisations in part a) and b), discuss which features appear to be best at differentiating between different ball types. For each ball type, are shape or texture features more informative? Which ball type is the easiest/hardest to distinguish, based on the calculated features? Which other features or types of features would you suggest for the task of differentiating between the different ball types and why?

Analyse and discuss your findings in the report.

Task 3: Object Tracking

Download from Blackboard the data files 'x.csv' and 'y.csv', which contain the real coordinates [x,y] of a moving ball, and the files 'na.csv' and 'nb.csv', which contain their noisy version provided by some segmentation and recognition for the football (e.g. frame-to-frame image segmentation of the target).

Implement a Kalman filter from scratch (<u>not using any method/class from pre-built libraries</u>) that accepts as input the noisy coordinates [na,nb] and produces as output the estimated coordinates [x*,y*]. For this, you should use a Constant Velocity motion model F with constant time intervals $\Delta t = 0.5$ and a Cartesian observation model H. The covariance matrices Q and R of the respective noises are the following:

$$Q = \begin{bmatrix} 0.16 & 0 & 0 & 0 \\ 0 & 0.36 & 0 & 0 \\ 0 & 0 & 0.16 & 0 \\ 0 & 0 & 0 & 0.36 \end{bmatrix} \quad R = \begin{bmatrix} 0.25 & 0 \\ 0 & 0.25 \end{bmatrix}$$

1) You should plot the estimated trajectory of coordinates [x*,y*], together with the real [x,y] and the noisy ones [a,b] for comparison. Discuss how you arrive to the solution.

2) You should also assess the quality of the tracking by calculating the mean and standard deviation of the Root Mean Squared error (include the mathematical formulas you used for the error calculation in your report). Compare both noisy and estimated coordinates to the ground truth. Adjust the parameters associated with the Kalman filter, justify any choices of parameter(s) associated with Kalman Filter that can give you better estimation of the coordinates that are closer to the ground truth. Discuss and justify your findings in the report.

Please see the Criterion Reference Grid for details of how the presentation will be graded.

Learning Outcomes Assessed:

- [LO1] Critically evaluate and apply the theories, algorithms, techniques and methodologies involved in computer vision.
- [LO2] Design and implement solutions to a range of computer vision applications and problems and evaluate their effectiveness.

Knowledge & Skills Assessed:

<u>*Subject Specific Knowledge, Skills and Understanding*</u>*: academic report writing, literature searching, referencing, algorithm development, project planning, computer vision techniques and programming skills.*

<u>*Professional Graduate Skills*</u>*: independence and personal responsibility, adaptability, verbal communication, written communication, creativity, critical thinking, IT skills, problem solving, research skills, effective time management, working under pressure to meet deadlines.*

<u>*Emotional Intelligence:*</u> *self-awareness, self-management, motivation, resilience, self-confidence.*

Career-focused Skills: *An understanding of the range of skills and attributes required by employers from computer vision field, a range of strategies to present skills and attributes to employers.*

Assessment Submission Instructions:

The deadline for submission of this work is included in the School Submission dates on Blackboard.

You must make an electronic submission of your work in **pdf** format (a concise report) through the assessment (TurnItIn) link on Blackboard for this component, together with a **zip** file (NOT in any other format, e.g. 7z, rar) containing all source code files by using the supplementary link on Blackboard for this component.
Please **note** that, in the report, you also need to include the main source code in the appendix. The maximum page limit of the report for this assessment is 10 pages (excluding the appendix).

Date for Return of Feedback:
Please see the school assessment dates spreadsheet.

Format for Assessment:
See CRG. Marks allocation for each task is distributed as below:

Task 1 (40%), Task 2 (30%), Task 3 (30%).

Feedback Format:
Written feedback via blackboard. Oral feedback can be given upon request from student.

Additional Information for Completion of Assessment:
This assessment is an individually assessed component. Your work must be presented according to the Lincoln School of Computer Science guidelines for the presentation of assessed written work. Please make sure you have a clear understanding of the grading principles for this component as detailed in the accompanying Criterion Reference Grid. If you are unsure about any aspect of this assessment component, please seek the advice of a member of the delivery team.

Assessment Support Information:
Assessment support will be provided during the workshop sessions near the time. Please consult the delivery team for any questions regarding this assessment.

Important Information on Dishonesty & Plagiarism:
University of Lincoln Regulations define plagiarism as 'the passing off another person's thoughts, ideas, writings or images as one's own...Examples of plagiarism include the unacknowledged use of another person's material whether in original or summary form. Plagiarism also includes the copying of another student's work'.

Plagiarism is a serious offence and is treated by the University as a form of academic dishonesty. Students are directed to the University Regulations for details of the procedures and penalties involved.

For further information, see www.plagiarism.org