COMP9517: Computer Vision

2023 Term 3

Group Project Specification

Maximum Marks Achievable: 40

The group project is **worth 40% of the total course marks**.

Project work is in Weeks 6-10 with deliverables due in Week 10.

Deadline for submission is Friday 17 November 2023 18:00:00 AEDT.

Instructions for online submission will be posted closer to the deadline.

Refer to the separate marking criteria for detailed information on marking.

Introduction

The goal of the group project is to work together with peers in a team of 5 students to solve a computer vision problem and present the solution in both oral and written form.

Group members can meet with their assigned tutors once per week in Weeks 6-9 during the usual consultation session hours to discuss progress and get feedback.

The group project is to be completed by each group separately. Do not copy ideas or any materials from other groups. If you use publicly available methods or software for some of the tasks, these must be properly attributed/referenced. Failing to do so is plagiarism and will be penalised according to UNSW rules described in the Course Outline.

Note that high marks are given only to groups that developed methods not used before for the project task. We do not expect you to develop everything from scratch, but the more you use existing code (which will be checked), the lower the mark. We do expect you to show creativity and build on ideas taught in the course or from computer vision literature.

Description

Solar panels provide a cost-effective solution to powering off-grid homes and devices using a renewable and clean source of energy. They convert sunlight into electricity by means of photovoltaic (PV) cells. Commercial solar panels usually come with an aluminium frame and glass lamination to protect the PV cells from environmental influences such as rain, wind, and snow. However, these protective measures cannot always prevent damage caused by mechanical impact from falling tree branches, hail, or from thermal stress. Damages may also be caused by errors in the manufacturing process.

As any defects can decrease the power efficiency of solar panels, it is important to monitor the condition of the PV cells. Visual inspection by human experts is very time consuming, and, apart from obvious cracks in the glass, many defects are not visible to the naked eye. Conversely, visible imperfections do not necessarily reduce the efficiency of a solar panel. Thus, to enable quick yet rigorous inspection of solar panels, more comprehensive scanning and automated analysis methods are needed.

Electroluminescence (EL) imaging is a non-destructive technology that allows high-resolution scanning of PV modules to visualize a broad range of imperfections and defects. It applies a current to the modules which induces EL emission that can be imaged using a digital camera. In the resulting images, defective cells appear darker than functional cells, because disconnected areas do not irradiate. The images can subsequently be analysed automatically using computer vision methods to detect and classify defects.

The goal of this group project is to develop and test computer vision methods for predicting the health of PV cells in EL images of solar modules.

Dataset

The dataset to be used in the group project is the ELPV dataset (see links and references at the end of this document). It contains 2,624 EL images of functional and defective PV cells with varying degrees of degradation extracted from 44 different solar modules. All cell images are normalized with respect to size and perspective, corrected for camera lens distortions, and manually annotated with a defect probability (a real-valued number from 0 to 1) and the type of solar module (monocrystalline or polycrystalline).

Task

The task is to classify cell images according to their probability of defectiveness. More specifically, automatic classifiers should predict whether a given image contains a cell that is fully functional (0% probability of being defective), possibly defective (33% probability), likely defective (67% probability), or certainly defective (100% probability). 4 classes

Methods

Many traditional, machine learning, and deep learning-based computer vision methods could be used for this task. You are challenged to use concepts taught in the course and other methods from literature to develop your own methods and test their performance. At least two different methods must be developed and tested.

Although we do not expect you to develop everything from scratch, we do expect to see some new combination of methods, or modifications of existing methods, or the use of more state-of-the-art methods that have not been tried before for the given task.

As there are virtually infinitely many possibilities here, it is impossible to give detailed criteria, but as a general guideline, the more you develop things yourself rather than copy straight from elsewhere, the better. In any case, always do cite your sources.

Training

If your methods require training (that is, if you use supervised rather than unsupervised classification approaches), you can use the same strategy as the creators of the ELPV dataset. That is, use 75% (1968) of the images for training, and the remaining 25% (656) for testing. Make sure to use stratified sampling when splitting the dataset. That is, randomly split the samples such that the training set and the test set have (approximately) the same proportions of samples in the different classes. Also explore ways to deal with class imbalance.

Even if your methods do not require training, they may have hyperparameters that you need to fine-tune to get optimal performance. In that case, too, you must use the training set, not the test set, because using (partly) the same data for both training/fine-tuning and testing leads to biased results that are not representative of actual performance.

Testing

To assess the overall performance of your methods, construct the 4x4 confusion matrix for each method, and calculate and report the overall accuracy and the F1 score. Do this for all test cell images together (monocrystalline + polycrystalline) as well as separately for each type (only monocrystalline and only polycrystalline).

Show these quantitative results in your video presentation and written report (see deliverables below). Also show representative examples of successful classifications as well as examples where your methods failed (no method generally yields perfect results). Give some explanation why you believe your method failed in these cases.

Furthermore, discuss whether and why your methods performed better or worse than the methods used by the creators of the ELPV dataset. Also discuss for which type of solar module (monocrystalline or polycrystalline) your methods work better (and possibly why). And, finally, discuss some directions for future research to further improve results.

Deliverables

The deliverables of the group project are 1) a video presentation, 2) a written report, and 3) the code. More detailed information on the deliverables:

Video

Each group will prepare a video presentation of at most 10 minutes showing their work. The presentation must start with an introduction of the problem and then explain the used methods, show the obtained results, and discuss these results as well as ideas for future improvements. For this part of the presentation, use PowerPoint slides to support the narrative. Following this part, the presentation must include a demonstration of the methods/software in action. Of course, some methods may take a long time to compute, so you may record a live demo and then edit it to stay within time.

The entire presentation must be in the form of a video (720p or 1080p mp4 format) of at most 10 minutes (anything beyond that will be ignored). All group members must present (points may be deducted if this is not the case), but it is up to you to decide who presents which part (introduction, methods, results, discussion, demonstration). In order for us to verify that all group members are indeed presenting, each student presenting their part must be visible in a corner of the presentation (live recording, not a static head shot), and when they start presenting, they must mention their name.

Overlaying a webcam recording can be easily done using either the video recording functionality of PowerPoint itself (see for example this YouTube tutorial) or using other recording software such as OBS Studio, Camtasia, Adobe Premiere, and many others. It is up to you (depending on your preference and experience) which software to use, as long as the final video satisfies the requirements mentioned above.

Also note that video files can easily become quite large (depending on the level of compression used). To avoid storage problems for this course, the video upload limit will be 100 MB per group, which should be more than enough for this type of presentation. If your video file is larger, use tools like HandBrake to re-encode with higher compression.

The video presentations will be marked offline (there will be no live presentations). If the markers have any concerns or questions about the presented work, they may contact the group members by email for clarification.

Report

Each group will also submit a written report (in 2-column IEEE format, max. 10 pages of main text, and any number of references).

The report must be submitted as a PDF file and include:

1. Introduction: Discuss your understanding of the task specification and dataset.
2. Literature Review: Review relevant techniques in literature, along with any necessary background to understand the methods you selected.
3. Methods: Motivate and explain the selection of the methods you implemented, using relevant references and theories where necessary.
4. Experimental Results: Explain the experimental setup you used to test the performance of the developed methods and the results you obtained.
5. Discussion: Provide a discussion of the results and method performance, in particular reasons for any failures of the method (if applicable).
6. Conclusion: Summarise what worked / did not work and recommend future work.
7. References: List the literature references and other resources used in your work. All

external sources (including websites) used in the project must be referenced. The references section does not count toward the 10-page limit.

Code

The complete source code of the developed software must be submitted as a ZIP file and, together with the video and report, will be assessed by the markers. Therefore, the submission must include all necessary modules/information to easily run the code. Software that is hard to run or does not produce the demonstrated results will result in deduction of points. The upload limit for the source code (ZIP) plus report (PDF) together will be 100 MB. Note that this upload limit is separate from the video upload limit (also 100 MB).

Plagiarism detection software will be used to screen all submitted materials (reports and source codes). Comparisons will be made not only pairwise between submissions, but also with related assignments in previous years (if applicable) and publicly available materials. See the Course Outline for the UNSW Plagiarism Policy.

Student Contributions

As a group, you are free in how you divide the work among the group members, but all group members must contribute roughly equally to the method development, coding, making the video, and writing the report. For example, it is unacceptable if some group members only prepare the video and report without contributing to the methods and code.

An online survey will be held at the end of term allowing students to anonymously evaluate the relative contributions of their group members to the project. The results will be reported only to the LIC and the Course Administrators, who at their discretion may moderate the final project mark for individual students if there is sufficient evidence that they contributed substantially less than the other group members.

References

ELPV Dataset. A Benchmark for Visual Identification of Defective Solar Cells in Electroluminescence Imagery. https://github.com/zae-bayern/elpv-dataset

C. Buerhop et al. A Benchmark for Visual Identification of Defective Solar Cells in Electroluminescence Imagery. European PV Solar Energy Conference and Exhibition (EU PVSEC), 2018. http://dx.doi.org/10.4229/35thEUPVSEC20182018-5CV.3.15

S. Deitsch et al. Automatic Classification of Defective Photovoltaic Module Cells in Electroluminescence Images. Solar Energy, vol. 185, June 2019, pp. 455-468. https://doi.org/10.1016/j.solener.2019.02.067

Released: 13 October 2023