EEEM066 Fundamentals of Machine Learning

Coursework Assignment (Autumn 2023)

Knife classification in real-world images

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Released: Saturday 21 Oct 2023 (end of Week 4)

Due: 10:00PM, Friday 01 December 2023 (end of Week 10)

Marks: This coursework will be marked out of 100, contributing to 25% of your total marks for this module

1 Introduction

In recent years, the number of crimes and offences by sharp knives has increased all over the world. In the year ending March 2022, there were around 45,000 offences involving a knife or sharp instrument in England and Wales. This was 9% higher than in 2020/21 and 34% higher than in 2010/11. There is critical need to develop AI weapon analysis system to allow officers to identify the make, model and sellers of knives, simply by taking a photo. Current methods of knife recognition and labeling, although functional, have been plagued by inefficiencies due to the immense strain on public resources and the potential for human error, exacerbated by the UK's expanding digital footprint. In this project you will develop a deep learning based system to classify knife images into different categories (classes).

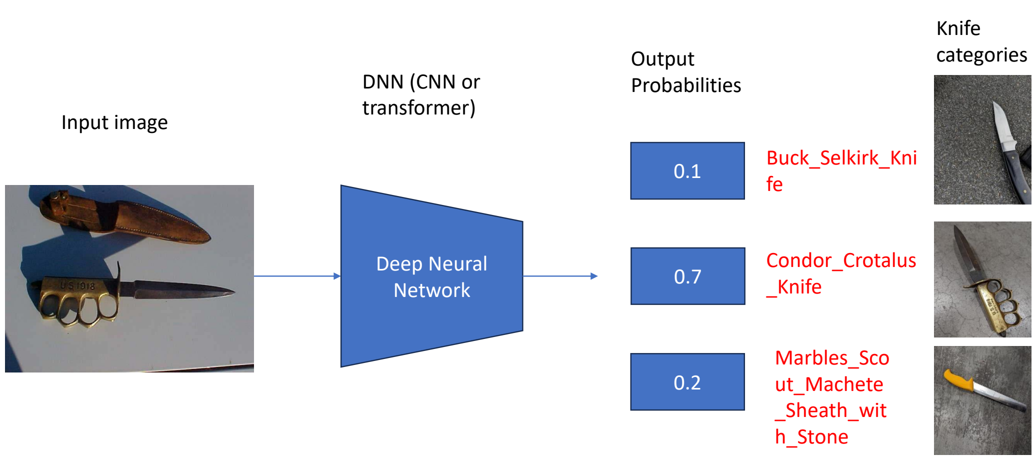

Figure 1: **Overview of a knife classification system**

The purpose of this coursework is to gain real-world development experience in design, training, and evaluation of a Deep Neural Network for fine-grained real-world knife classification.

1.1 Dataset

The training dataset consists of around 9928 knife images in 192 classes. The test dataset consists of 351 images. The training, validation and test splits are provided. The performance of the model will be evaluated using the mAP. Click here to download

1.2 Compute Platform

To do this coursework you will need to connect to Google Colab. Please refer to your lab sheets of **Colab** for more tutorials.

1.3 Getting Started

To well understand the motivation, definition, basic methods, and evaluation metrics, we suggest reading following papers before you start:

- Fine-Grained Image Analysis With Deep Learning A Survey
- Weapon Classification using Deep Convolutional Neural Network

We have lab sessions provided on the tutorial of Python and PyTorch to train and test CNNs for image classification, coupled with knowledge from the associated lectures. The PyTorch Introductory lab sheet and the lecture slides from these sessions remain available on SurreyLearn in case you missed any classes. All these are helpful for this coursework assignment.

1.4 Support in Programming

We have provided a reference code base in this Github repo. For any problems, please feel free to open an issue.

1.5 Lab Support

Lab sessions on Tuesday afternoons and Friday mornings are there to assist you with both lab exercises and the coursework. The labs are in-person and run with the support of four lab demonstrators:
Al-Hussein Abutaleb (a.abutaleb@surrey.ac.uk),
Haosen Yang (h.yang@surrey.ac.uk),
Kam Woh Ng (kamwoh.ng@surrey.ac.uk),
Swapnil Bhosale (s.bhosale@surrey.ac.uk).

Again, you may find detailed schedule for these labs in your timetable.

Note, you only need to attend **one of the two scheduled labs per week**.

2 Deliverables

You must run your project in the Colab to undertake the task in this coursework. For the report, you must document the experiments performed using your software; You should detail the method used and the numerical and qualitative results (**including the running evidence**). This coursework is worth 25% of overall mark. The University has moved to **electronic submission of the coursework on SurreyLearn**.

What to submit: You should submit a single **PDF-format** report, along with the running evidence, *e.g.*, the log file. You must format your submission using the provided `word or latex document template` and convert the final report to the PDF format for submission.

3 Learning Outcomes

After completing this coursework along with the designated lectures, you should be able to:

1. **Design** and **implement** a deep neural network for knife classification, a challenging fine-grained object recognition problem.
2. **Apply** appropriate training strategies to learn a discriminative CNN for representation learning.
3. **Conduct** a scientific investigation into image classification systems in general and analyse the experiment results.

4 Plagiarism

You must complete this coursework individually. If you copy code or text from the web, or another student, and include it in your project without clear attribution, then you have committed plagiarism. Undetected plagiarism degrades the quality of your degree, as it interferes with our ability to assess you and prevents you learning through properly attempting the coursework. Consequently if we suspect plagiarism you will referred to an Academic Misconduct Panel which may carry with it academic sanctions.

5 Main Assignment Tasks

During this project, we will walk you through a series of related experiments. Some of the main tasks are:

1. First, you need to run the demo code successfully without error and make sure fully understand every line of code.
2. You should experiment with different settings (those parameters such as the learning rate, weight decay, optimizer and etc) to learn how to train deep models effectively.
3. You should experiment with different CNN architectures. This might include the use of existing architectures (like ResNet) or modified versions of those architectures (*optional*).

Please don't distribute this dataset or use it for any other purposes.

6 Starting Early!

Making a solid project as this takes time and efforts. You should start this coursework early to reduce stress level and avoid disappointment in hitting the deadline.

7 Marking Scheme

Marks will be awarded according to the following marking scheme. You should attempt each of these coursework "requirements" for which you will be awarded a mark up to the allocated mark budget, based on your report/results.

1. **Exploration of Hyper-parameters (40%)**: Evidence of experimentation with hyper-parameters, *i.e.*, parameters used to control the training of the network, rather than parameters of the network itself. An example of hyper-parameters is the learning rate (or schedule of different learning rates) or the number of training epochs. A passable solution will explore one of these. A merit solution will explore several. A distinction solution will include good quantitative conclusions as to the impact of varying these parameters. All solutions should include written conclusions alongside any results presented.
2. **Deep model architectures (30%)**: Evidence of experimenting with different deep architectures (CNN or Vision transformer). A passable solution would test the dataset using standard networks suitable for image classification such as the EfficientNet or ResNet architectures (which are built in torchvision). A merit solution would explore the effect of changing some parameters/ or adding/removing layer(s) from those networks. A distinction solution would do all of the above and include evidence of testing your own network design. In all cases experimental results should be presented alongside your own observations, findings, and reflections. A passable reporting will include just visual results, *e.g.*, showing sample images and indicating their classification results. A merit/distinction level reporting will ask for quantitative result measured with performance metrics on a test set, and proper analysis and discussion.
3. **Evaluation and Scientific Method (30%)**: This component of the mark budget specifically rewards good scientific methodology in the training and testing of your deep model. Aspects of your work that will gain you high marks under this category are the ability to conclude/argue clearly and succinctly as to why you are seeing the results you do, the ability to correctly use the partitions of training data, *i.e.*, not testing with your training data or inferring incorrect conclusions based on, *e.g.*, training loss. Good discussion of graphs and quantitative data in the report etc.
4. **Extra Credit (optional) (20%)**: If you have your own idea (data augmentation, different loss function, ensembling etc.) then we will award up to a further 20% based on technical merit. Remember the innovation should be based on Image Processing and Deep Learning (which we are assessing) and presentation of the document etc.

Note, ***you cannot score > 100% overall for this coursework***.

8 Submission Guidance

To format your report submission, please strictly follow the report template provided at SurreyLearn, see the tabs `coursework-report-word/latex`, ***not allowing any format changes*** for either one. To make the structure of report clear, you are suggested to cover the marking points one by one as listed in Section 8.

The report length is limited up to **5 pages** *excluding* references (***The overrun pages will occur penalty, 1 point per page, upto 5 points***).

Except the report, **the log file** for model training and evaluation is also needed as part of your submission. Note, the code base we provide can generate the log file.

You need to convert your final report into the **PDF** format for submission.

9 Feedback

In line with University regulations, you will receive feedback within 3 teaching weeks of the deadline for this coursework. This will comprise an overall mark and some written feedback against each of the criteria above.

10 Extensions

No extensions will be granted to this coursework unless in exceptional circumstances. Even then, extension requests must be made via the Extenuating Circumstances (ECs) process as your lecturer is not permitted to grant adhoc extension requests whatever the reason.