ME4 Machine Learning - Tutorial 10

Lecture 10 covered machine learning in the real world. This tutorial aims to illustrate some of the concepts by giving you a physical problem and asking you to solve through ML techniques. As usual, you will use Python and Scikit-learn to implement this.

Note: this tutorial has parts which must be submitted as coursework. While for most of the tutorial content you are encouraged to collaborate and learn from each other, sharing answers to these assessed sections will constitute plagiarism and be treated accordingly. The tutors have been instructed not to provide help with these questions, however, you may ask generic questions to help your overall understanding.

1 The problem

An object of mass m kg sits on a horizontal surface. Two horizontal forces are applied to this; both are expressed as magnitudes f_1 N and f_2 N, and respective angles f_{1ang} degrees and f_{2ang} degrees, taken anti-clockwise relative to the x axis. We wish to predict whether or not the object will slip under these forces. This is illustrated in Fig. 1.

2 Data set 1

A set of training data has been generated for $m = 3$, $f_1 = 18$ and $f_{1ang} = 20$ with the second force being varied. The output of whether or not the object will slip is recorded under the heading "slips"; 1 indicates that it does and 0 otherwise. The data from this is provided in slip_data.csv.

Do you think that a support vector machine or a neural network would be the best to fit this? Pick one and train it on the data. [Hint: if using SVM, the following parameters are good: C=1000, gamma='scale', kernel='rbf'. If using neural networks, the following parameters work: tanh activation functions with softmax on the output, one hidden layer of 4 nodes, and training with 1200 epochs - you may be able to find better parameters though (although you are not asked to do this!). The standard scaling approach, discussed in the lectures, was used; this can be implemented easily with StandardScaler() from scikit learn.]

Take $f_1 = 18$, $f_{1ang} = 20$ and $m = 3$, and plot a 2D image indicating when the object will slip in the range $0 \leq f_2 \leq 40$, $0 \leq f_{2ang} \leq 360$, with f_2 on the x axis and f_{2ang} on y. You should not include a scatter plot of the underlying data, positions of the support vectors or any other lines on your plot. The image (and others in the submission) should just indicate what angles and force magnitudes cause

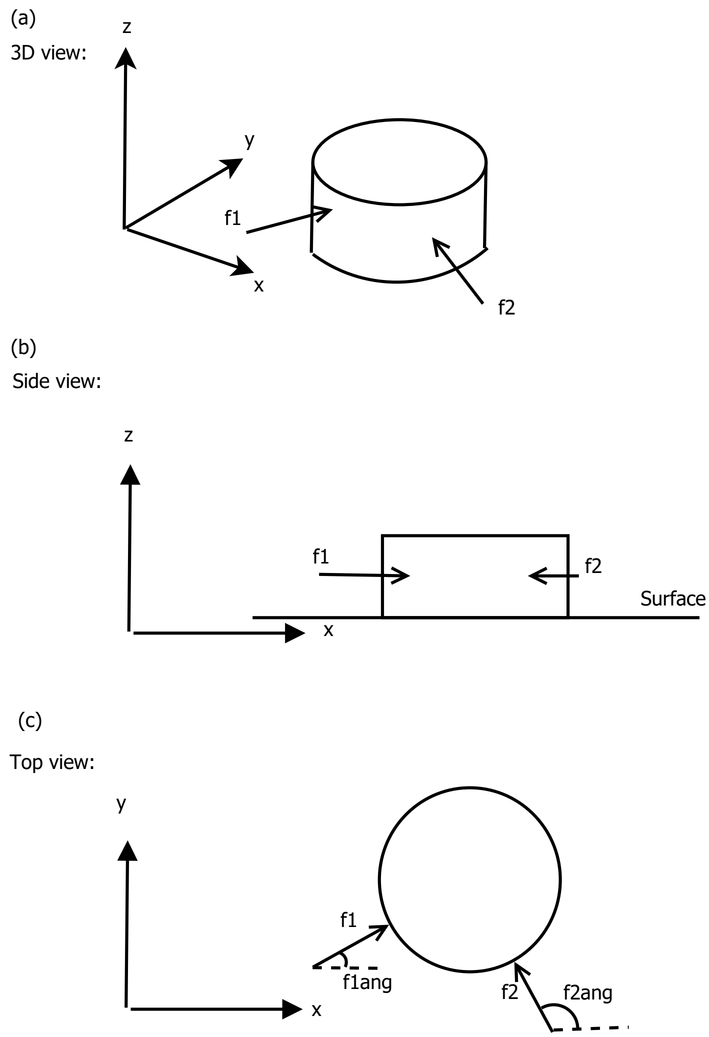

Figure 1: Diagram of the physical setup.

slip or otherwise, via the colour of the plot. Make sure to indicate on your plot which algorithm you used. This is part (A) in the submission.

Write a short (target 1 line for each answer, and no more than 2 lines – any text more than this will not be read.) response to each of the following questions - these form part (B):

1. Why did you choose the machine learning algorithm you did?
2. What are the pros of using machine learning for this task, compared to a more traditional engineering approach?
3. What are the cons of using machine learning for this task?

Produce the same decision function image as above, where you calculate a decision about whether the object will slip or not for each pixel and use these to produce an image, except now use basic friction rules rather than machine learning and use a value for the coefficient of friction of $\mu = 0.5$. This image is part (C) in the submission. You do not need to submit your mathematical working. How do you think this fits with the prior solution?

3 Data set 2

It is possible to extend this to the case where the first force varies too (however, mass remains constant with $m = 3$). A second dataset has been provided for this: slip_data_full.csv.

Use a support vector machine to fit a classifier to this; the parameters described before (C=1000, gamma='scale', kernel='rbf') would be well suited. Plot the decision function when $f_1 = 10$, $f_{1ang} = 30$. This is part (D) in the submission.

Compare this to the analytical decision function you see with the new force for f_1 (use the same equations from part (C)), but note that you should not submit anything for this comparison.

Provide a short answer (1-2 lines as before) to question (E):

1. The dataset has significantly more points (10000 vs 1000) - why is this change necessary?

4 Submission

Submit the following parts: your decision function image for data set 1 - (A), your short answers to the questions (B), your true decision function (C), your SVM decision function for $f_1 = 10$, $f_{1ang} = 30$ (D) and your answers to the question set (E). All responses should be marked with these labels. Place these all into a single PDF document containing your name in the filename, and your imperial username at the top of the first page, and submit this. Note that we reserve the right to award zero marks to any coursework not following the instructions given (e.g. submission of Word documents). Note that short answers are requested and longer answers may lose marks/not be read fully.