ME 2016
Fall Semester 2007
Computing Techniques 3-0-3

Homework Assignment 5

Curve Fitting – Creating an Engine Model

Due: Friday, October 5, 2007 on the hour before class

Description and Outcomes

In this assignment, you will use curve fitting to create models for a car engine based on experimental data.

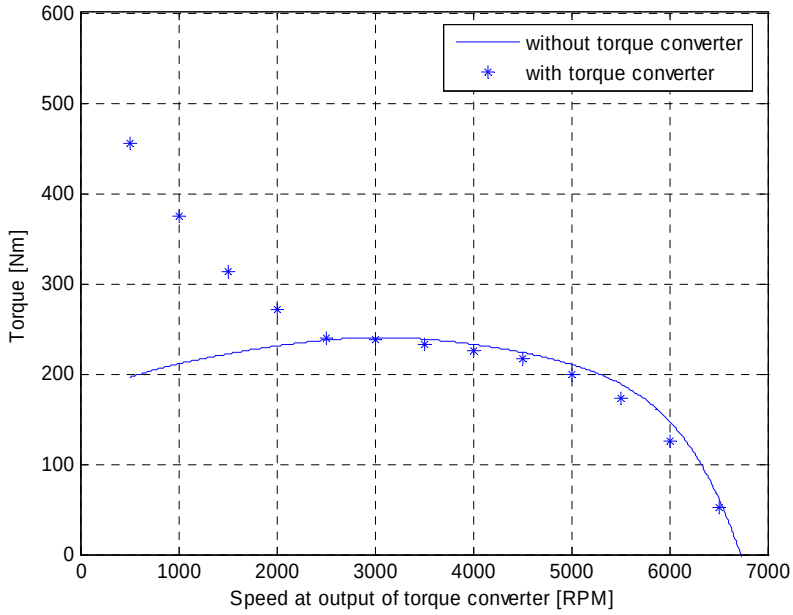
The learning objectives of this assignment are:

- to increase your understanding of curve fitting
- to learn how to implement curve fitting in Matlab
- to continue developing as an independent learner of Matlab features
- to improve your debugging skills

Background

In several of the previous assignments, you have used a polynomial model to define the behavior of a car engine. In this assignment, you will create such a model yourself from measurement data. You will use the curve fitting techniques discussed in class.

In this assignment, you will also learn something about the behavior of torque converters. Remember: a torque converter is a hydraulic device that performs the function of a clutch – it allows the engine to idle when the car is stopped. However as you can see from the data set below, it also amplifies the torque when the car is moving slowly, allowing the car to accelerate faster. At larger car velocities, on the other hand, the torque is slightly smaller than the torque produced without a converter, indicating that there are some losses (that is why most torque converters have a by-pass clutch that is engaged when the car is cruising).



The focus of this assignment is to learn about the different Matlab functions for polynomial curve fitting, and to critically assess the properties of the resulting models. Since we are about half-way through the semester and you are becoming more and more familiar with the style of

problem solving that we expect in this course, we will provide fewer detailed instructions than in the previous assignments and ask you to think more like an engineer solving a real modeling problem rather than a student trying to get a good grade on a problem that has been carefully formulated and constrained by the instructor. Answer the questions in the tasks below as if you were convincing your boss that your choice of model is indeed the best choice. Managers like to see graphs to make the numbers come to life.

The dataset for the engine with torque converter consists of pairs of RPM and torque (Nm) values:

RPM:	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500
Torque:	455	375	313	271	240	237	233	226	216	200	173	125	51

Tasks

Task 1: Demonstrate your understanding of theoretical foundation of curve fitting

Given the data set (x_i, y_i) with *n* data points, formulate a method for finding the best fit coefficients A, B, and C of the curve:

$$y = Ax^{-B}e^{-x/C}$$

Clearly explain how you would solve the problem and show your derivation. Make sure to list your assumptions. You can submit this on a separate piece of paper written in pencil or pen. Make sure to staple your solution to the rest of your report.

Task 2: Explore and compare different polynomial curve fits using Matlab.

Create a script (engine_model_curvefit_XYZ) that defines the dataset above and compares polynomial curve fits with orders: 1, 3, 6, 8 and 12.

You will notice that the Matlab function polyfit may not work well for large orders. You will have to use the advanced form of polyfit in which the variables S and MU are also used. Create graphs to support your critical evaluation in Task 3.

Task 3: Critically evaluate the polynomial curve fits.

Based on your results in task 2, answer the following questions. Include graphs to support your answers.

Question 1: Do you notice any characteristics in the models that you know cannot possibly match the behavior of a real car engine?

Question 2: Which metrics would you use to determine the goodness of fit?

Question 3: Which model would you recommend to be used in a car simulation? Justify your answer.

Report

Turn in a brief report in MS Word containing the following:

1. A copy of all your Matlab code.
2. A copy of all your figures you generated.
3. Your answers to all the questions in task 3.
4. A statement of collaboration (see below) – include this even if you did not collaborate with anybody

You don't have to scan in your answer to task 1, but make sure to staple it to the hardcopy of your report before turning it in.

Evaluation Criteria

A detailed grade sheet for this assignment is provided as a separate file on the course web-site. Print out this sheet, fill in your name, and staple it to the front of your submission.

Submission

1. **Hardcopy in class:** At the *beginning* of class, hand in a hardcopy that includes the grade sheet and your report. Make sure you staple everything together so that we don't lose anything. (no staple = incorrect submission)
2. **T-square:** save all your files in a zip-file called HW5.FamilyName.FirstName.zip (replace FamilyName and FirstName with YOUR names) and submit this file in the Assignments section of T-square. The zip-file should contain: your Matlab function and script, and your report. The deadline for electronic submission is ***on the hour before the beginning of class***. (For instance, if your class starts at 2:05PM, then the assignment is due at 2:00PM).

NOTE: it is best to use the "Save Draft" feature on t-square. This will allow you to resubmit as many times as you want anytime before the deadline. At the deadline, t-square will automatically submit the current draft — no action is required on your behalf.

Late Submission

Remember that the deadline for this assignment will be strictly enforced. After the deadline has passed you will receive a late-penalty. Don't wait until the last minute to get started! We repeat here the policy that is included in the syllabus:

Late Submission

T-square will be set up such that late submissions cannot be submitted electronically. We will accept late homework but with the following penalties. Submit by noon Saturday and receive 20% off of your grade. Submit by noon Sunday and receive 40% off. After noon on Sunday, no more partial credit will be awarded. If you are submitting late, e-mail the electronic version and bring a hardcopy to the office of your instructor (Section A: E-Jiang.Ding@ipst.gatech.edu, IPST 378; Sections C&D: chris.paredis@gatech.edu, MARC 256). If you plan on submitting late, a quick e-mail by the deadline would be appreciated so that we can make appropriate plans for grading your assignment.

Collaboration

We would like to re-emphasize the policy on collaboration. Collaboration is encouraged. Discussing the assignments with your peers will help you to develop a deeper understanding of the material. However, "discussing the assignment" does not mean solving it together; it does not mean asking your friend to debug your code for you. I encourage you to discuss how to approach the problem, which Matlab functions to use, or how to interpret the results, but I do expect each student to turn in a report and Matlab functions that reflect the student's individual work. Do not copy code from another student. Do not copy parts of other electronic documents. In general, an activity is acceptable if it promotes learning by you and your peers. For example, you learn from discussing alternate solution approaches with your friend, but you don't learn from blindly copying your friend's code. To avoid any confusion, each homework solution should explicitly identify the students with whom you collaborated and what the extent of the collaboration was. Any copying on homework and/or exams will be dealt with severely and reported to the Dean of Students – No exceptions. If you have questions about this collaboration policy, do not hesitate to ask your instructor.