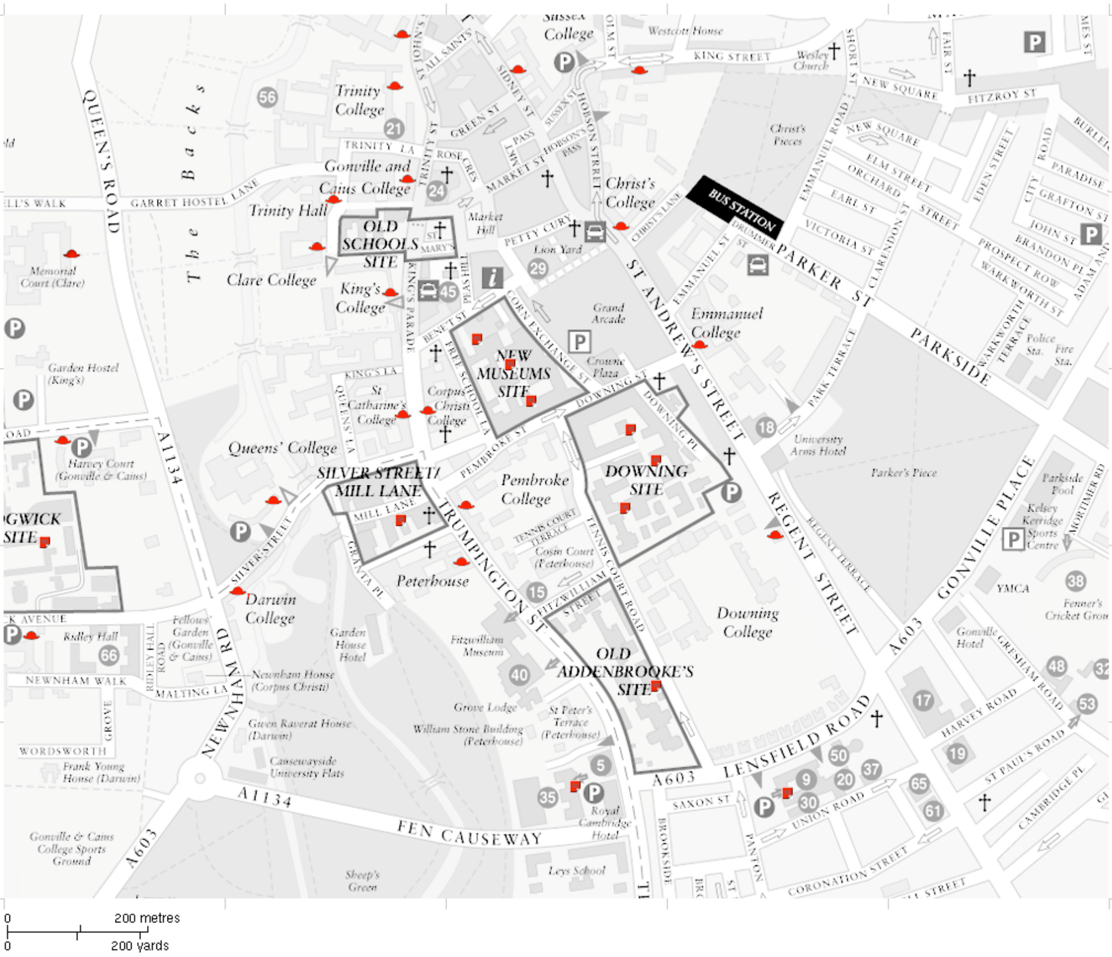
TRAVELLING STUDENT

Deadline: 13 January 2015

You are organising an end-of-term party tomorrow, and having worked so diligently for your supervisions, you have not yet had the time to invite your friends. Being somewhat of a traditional person, you would like to surprise them with a nice calligraphic invitation on real heavy weight paper, which you now need to distribute by hand to their pigeon-holes. While contemplating this, you realise that you have to hand in some late coursework to the Engineering department, and that you also promised to hand in work for some of your friends on your staircase who are in other departments. You take a map of Cambridge, and mark all the destinations you need to visit with red (Porters' Lodges, and departmental reception desks), which ends up looking like this:



What is the shortest route that visits all the places, starting from the Engineering Laboratory reception? There is little time left, as you still have to go shopping for the party, so you want to quickly finds a reasonably short route, which is probably very close to the shortest possible route. For simplicity, you can use the Euclidean distances between the destinations (i.e. "as the crow flies", and you wish you were a crow now...), ignoring the street level structure of the town. Your route does not need to come back to Engineering.

Tasks

1. Measure and record the coordinates of the target destinations. Explain how you did this.
2. Write a program that uses simulated annealing to find a reasonably short route touching each target destination.
3. There are potential errors in any measurement such as the one in Task 1. Investigate the robustness of your solution to these kinds of errors by randomly perturbing the coordinates by various amounts and running the program several times.

Admin

Just as before, please hand in your report electronically to David Gautrey (dpg23, IN1-07) or via Moodle. Make sure that **your name does not appear in the report**, or in the file name, only your Coursework Candidate Number (CCN).

This assignment counts for 25% of your final grade, and you should be spending about 8 hours on it. Questions on the assignment should be directed to Gábor Csányi (gc121).

Background

The above problem is an example and a prototype of a kind of optimisation problem that is ubiquitous not just in engineering, but in science and mathematics as well. Clearly, one way of solving it is to try all the possible solutions and select the best one. The number of possibilities rises rapidly (exponentially) with the size of the problem (in this case, with the number of destinations), and this strategy quickly becomes impossible to carry out. It is an open question whether an algorithm can be found that definitely (deterministically) solves the problem in polynomial time, taking $O(N^k)$ steps, for some k. However, there are many ways of finding "very good" solutions rapidly.

The "Travelling Salesman" problem, as it is usually called, is a member of a large class of very hard optimisation problems, each of which is such that if you have an algorithm to solve one efficiently, you can solve all other problems in that class (called "NP-complete" which stands for "non-deterministic polynomial complete"[*]) very efficiently as well. Different problems in this class can often be mapped into one another.

[*] This is a strange phrase to describe a problem. An NP problem is such that if you had a non-deterministic computer (specifically, a non-deterministic Turing machine), you could solve the problem in polynomial time. Furthermore, an NP problem is such that if someone gives you the solution to it, you could verify that it is indeed the solution in polynomial time using a normal Turing-equivalent machine.