Topics in TCS: Final Projects

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Your final project is designed to be a more open ended assignment than the class presentations, because I want *you* to think hard about what is the right way to present some more complex material. The projects listed below are merely suggestions, you should poke around and find some topic that is suitable for a final paper. Keep in mind that I do not want you to regurgitate the proof. I want you to figure out what are the key steps in the proof, and explain the context of the results. Your final output will be a 4-6 page writeup, and I'll grade you both on how well you understand the math but also whether or not I feel like you've been able to capture the key ideas in the results you're describing, without getting too bogged down in the details. We will also have short (20 minute) in class presentations at the end of the semester. **Whichever topic you choose, you should explore more than just the references I've given below**.

Due Dates: First Draft (May 7th), Final (May 16th), Presentations (May 7th, May 12th, May 14th)

Project Suggestions

- **Tree Embeddings** (Lars)

  Description: In class, we will see some applications of low-distortion embeddings. The embedding into trees given in `www.cs.berkeley.edu/~satishr/logn.ps` is one of the most versatile results in this area.

- **Mutiway Cut** (Nicolas)

  Description: The earth-mover metric has been a powerful tool in approximation algorithms since its introduction in `http://www.cs.technion.ac.il/~rabani/Papers/CalinescuKR-SICOMP-revised.pdf` which gives an elegant and simple rounding algorithm.

- **Oblivious Routing** (Eben)

  Description: There are by now many expositions of how to construct oblivious routing schemes from tree decompositions. See for example `http://www.dcs.warwick.ac.uk/~harry/pdf/opthierarchical.pdf` but there are many other sources. You could also present one of the earlier papers on this topic instead.

- **Multiplicative Weights** (Jiaming)

  Description: Multiplicative weights give a general framework for reducing a more complex optimization problem to solving a sequence of simpler ones. Check out the following survey: `https://www.cs.princeton.edu/~arora/pubs/MWsurvey.pdf` and look at the weighted majority application, and explore some of its applications (e.g. solving zero sum games).

- **Approximation by Ellipsoids** (Allen)

  Description: All convex bodies can be loosely approximated by an ellipsoid, and in many settings this allows us to reduce problems about general convex bodies to simpler ones about ellipsoids (at some loss). See Chapter 13.4 in Matousek or Chapter 5 in Barvinok.

- **Weak Perfect Graph Theorem** (Michael)

  Description: A graph is perfect if and only if its complement is perfect. There is a nice exposition of this famous result in Chapter 12.1 of Matousek

- **Measure Concentration** (Ariel)

  Description: In high dimensions, functions are well concentrated around their means. There are various geometric problems underlying this phenomenon such as *isoperimetry*. There is a nice introduction in Chapter $14.1-14.2$ in Matousek.

- **Minimizing Submodular Functions** (Cesar)

- **Maximizing Submodular Functions**

  Description: Submodular functions are a natural discrete analogue of convex functions, and there are interesting ways to reduce minimizing a sub modular function to a problem we already covered in class, namely minimizing a convex function on a convex set. You could also cover approximation algorithms for the maximization version. For the minimization problem see `http://theory.stanford.edu/~jvondrak/CS369P-files/lec17.pdf` and for the maximization see `http://theory.stanford.edu/~jvondrak/CS369P-files/lec16.pdf`.

- **Lower Bounds for Metric Embeddings** (Tyler)

  Description: In class, we proved upper bounds for metric embeddings. See Chapter $15.3-15.5$ for examples of lower bounds. There is also a nice lower bound outlined in Exercise 2 in 15.4, which combined with that section itself may make for a nice topic.

- **Iterative Rounding: Generalized Assignment Problem** (Bryan)

- **Iterative Rounding: Bounded Degree Spanning Trees**

  Description: Iterative rounding is a powerful method in approximation algorithms, which departs from our usual relax then round framework. Instead one works with the relaxation iteratively by showing that you can always make progress towards an integral solution one variable or constraint at a time, by repeatedly solving the linear program. Two textbook examples are the approximation algorithm for the generalized assignment problem:

`http://www.columbia.edu/~cs2035/courses/ieor6400.F07/st.pdf`

And for the bounded degree spanning tree problem:

`http://theory.stanford.edu/~jvondrak/CS369P-files/lec15.pdf`

These are more challenging topics, but are very cool!

- **Your Choice!**

  Feel free to choose some relevant topics from Matousek or Barvinok, or other sources on the web