Applying SnapVX to Real-World Problems

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- Other resources (MLOSS Paper, website, documentation, ...) describe the math/software side of SnapVX
- This presentation is meant to explain how SnapVX can be applied to real-world problems
 - Assumptions: Basic knowledge of optimization, graph theory
- For additional examples of how to solve machine learning problems in SnapVX, see http://snap.stanford.edu/snapvx/#examples

Putting a problem in SnapVX form

- Step 1: What is the network?
- Step 2: What are the objectives, constraints at each node and edge?
- Step 3: Are they convex?
 - If not, how can you form a convex relation of the original problem?
- ► Step 4: Solve!
- In this presentation, we use a running example to illustrate the process (predicting housing prices)
 - Example comes from "Network Lasso", KDD 2015

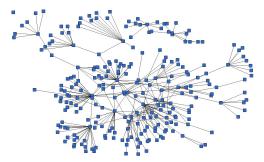
Step 1: What is the network?

Large problems can often be represented as a network

- Nodes series of subproblems
- Edges relationships that define the coupling between the different nodes (entities)

▶ Examples: cyber-physical, social, financial transactions, ...

- Representational networks count too! (i.e. graphical models)



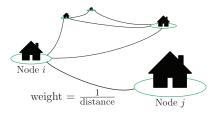
Application — housing price prediction

- Given: A set of houses
 - Attributes: latitude, longitude, general features (# of bedrooms, square footage, ...)
- ► Goal: Build a regression model to predict the sales price of a house



Modeling the problem on a network

 Build a housing network where neighboring houses (nodes) are connected by edges



Now, each node will solve for a vector x_i, the parameters weights in the regression model used to predict the price of house i

What are the objectives and constraints?

- Housing nodes want to build a good model to accurately predict price
 - For example, linear regression: $f_i(x_i) = ||Ax_i b||_2^2$
 - \boldsymbol{A} are the feature values, \boldsymbol{b} the sales price
- However, we are building a linear regression model with only one training example (the house itself!)
- This is where the edge objectives come in...

Edge objectives

- Housing edges connect nearby houses
 - Intuitively, we'd want nearby houses to share similar (or the same) regression model
- Depending on how we want the penalty to work, we define edge objectives to yield our desired behavior!
 - Network Lasso $(||x_i x_j||_2)$ penalty encourages the graph to cluster into groups of nodes which share common models of x
 - This can be thought of as simultaneously solving for a price prediction model while also discovering neighborhoods in the real estate market
- Other penalties can lead to different behaviors
 - For example, with Laplacian regularization $(||x_i x_j||_2^2)$, the housing model x_i will be unique at every house, but will change slowly and smoothly across the network

Tradeoff between node and edge objectives

- For each house, there is a tradeoff between accurately predicting its own price (the node objective), and agreeing on a similar model as its neighbors (the objective at each edge)
 - In other words, should it pick a "local" or a "global" model?
 - Too local: there is not enough data to build a robust classifier, so we will overfit our model
 - Too global: houses will be forced to share common models with houses very far away on the other side of town
 - And with real estate, location is everything!
- SnapVX makes it easy to tune these parameters to find the right values for each application
 - Edge weights, regularization, etc...

Solving the problem

- > Once you've set up your graph and objectives, check convexity
 - If non-convex, there are many available resources to help "convexify" your problem (see "Convex Optimization" by Boyd and Vandenberghe)
- Now, just plug into SnapVX and solve!

Sample applications

- For more details on the housing example, see Hallac, Leskovec, and Boyd, KDD 2015
- Lots of common problems from many different fields can be efficiently solved via SnapVX
 - Event detection
 - Consensus and exchange
 - Pagerank
 - Fixed Routing
 - Network inference
 - Information diffusion
- See the SnapVX website or the "Examples" folder in the software download for additional concrete examples!

Summary

- SnapVX: http://snap.stanford.edu/snapvx
- ► A computationally tractable method of leveraging network data
- ► Fast, scalable, and robust
- > The same setup can solve a variety of different problems

Thanks for reading!

