# A Network Tour of Data Science
## Final Project

# Learning US Senate voting behavior from bill sponsorship profiles

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# Project Overview and Data

- **Goal:** predict votes of all senators based on the sponsorship information of each bill (sponsored by a senator)

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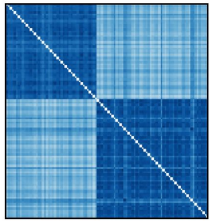
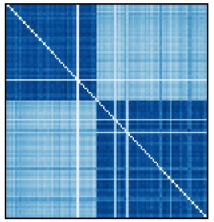
- **Data:** collected from ProPublica Congress API from January 1997 to 2018 Decembe
  - 6834 votes, 11 Senates (from 105 to 115), 231 senators
  - Adjacency is built considering the senator's positions (1 if senator i voted the same as j  0 otherwise)

# Adjacency Matrices

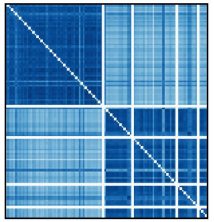
105 ~ 612 votes



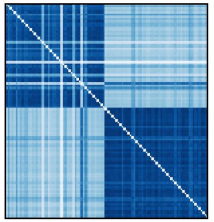
106 ~ 672 votes



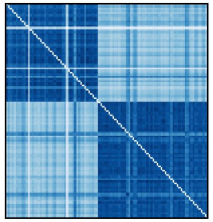
107 ~ 633 votes



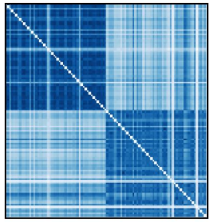
108 ~ 675 votes



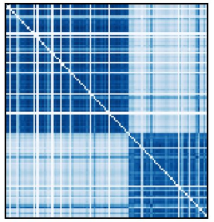
109 ~ 645 votes



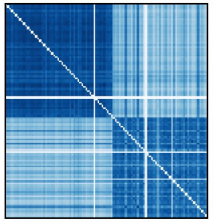
110 ~ 657 votes



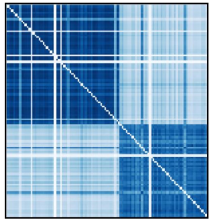
111 ~ 696 votes



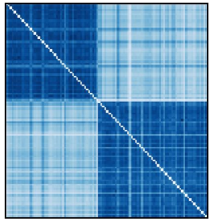
112 ~ 486 votes



113 ~ 657 votes

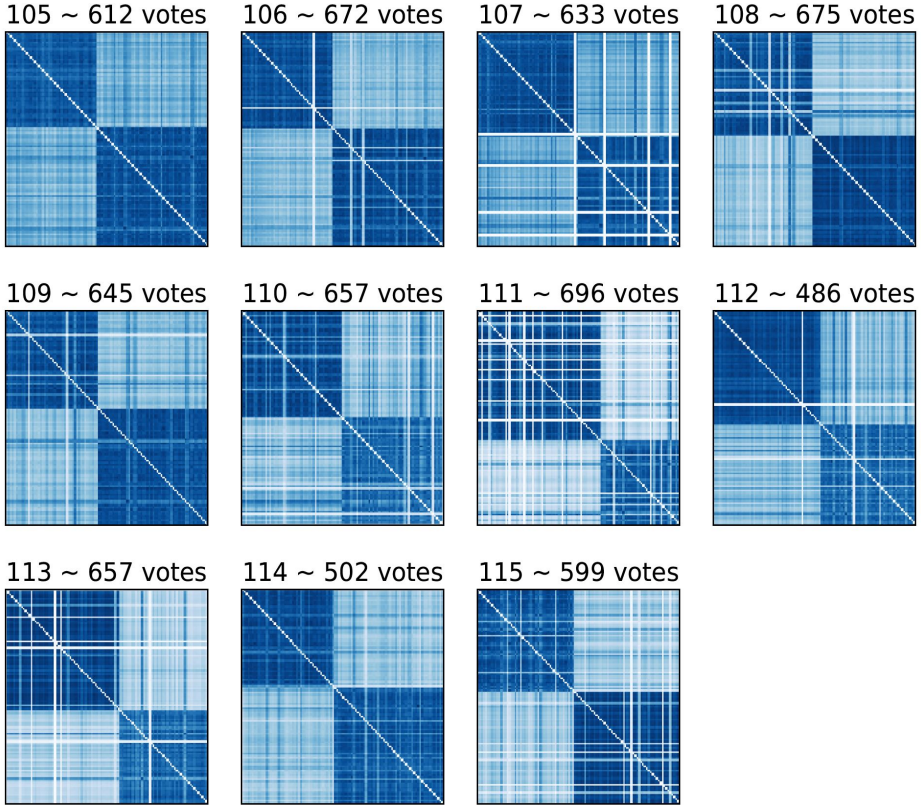


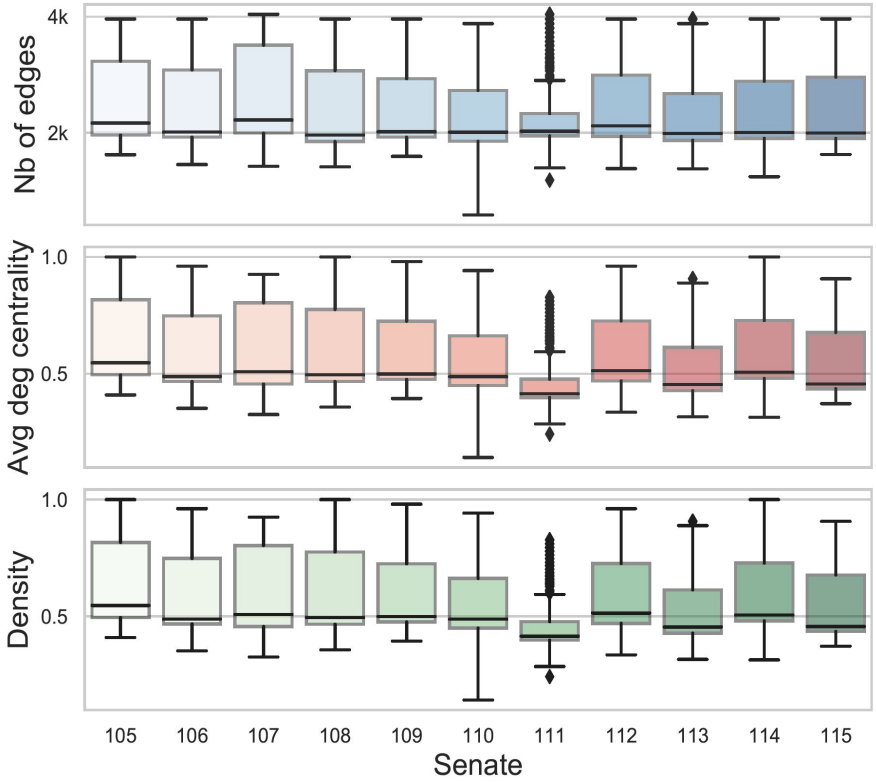
114 ~ 502 votes



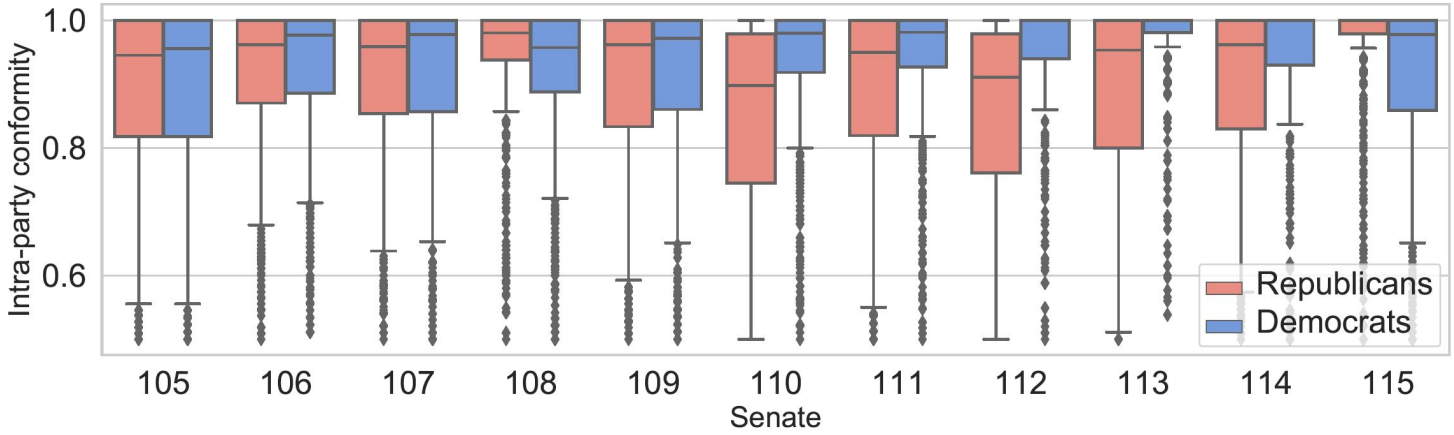
115 ~ 599 votes

# Adjacency Matrices



# Concordance and Dominance



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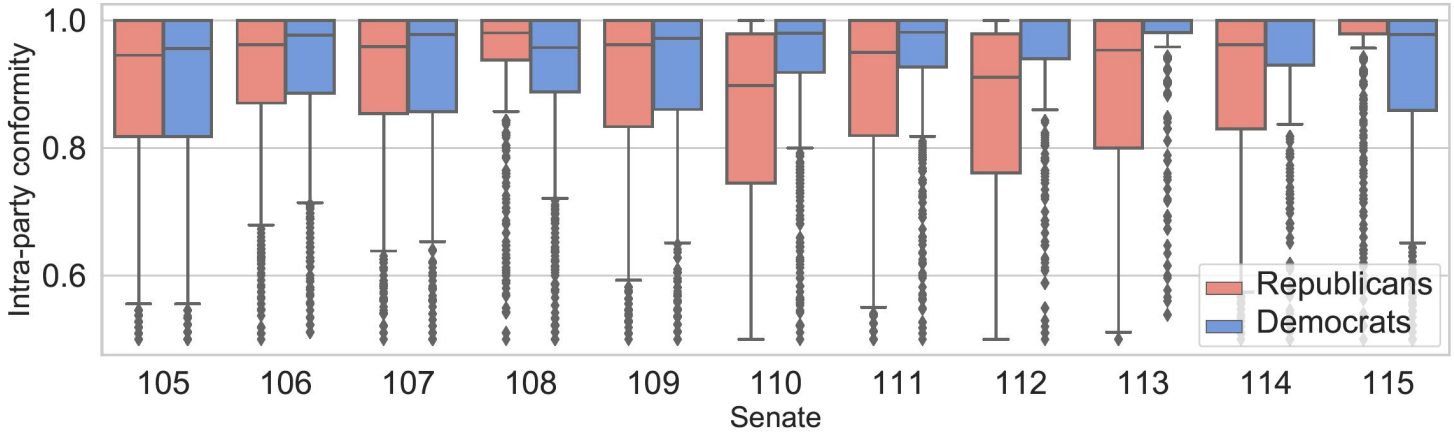


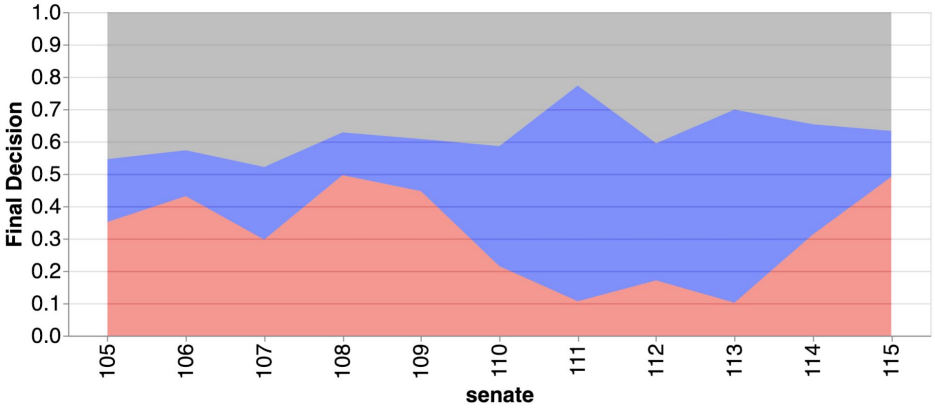

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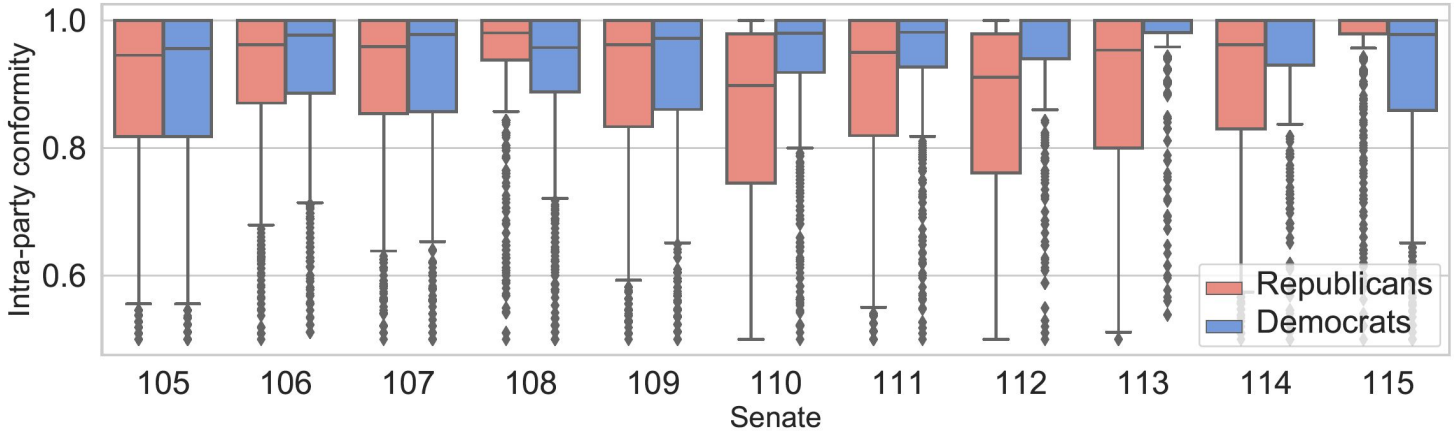
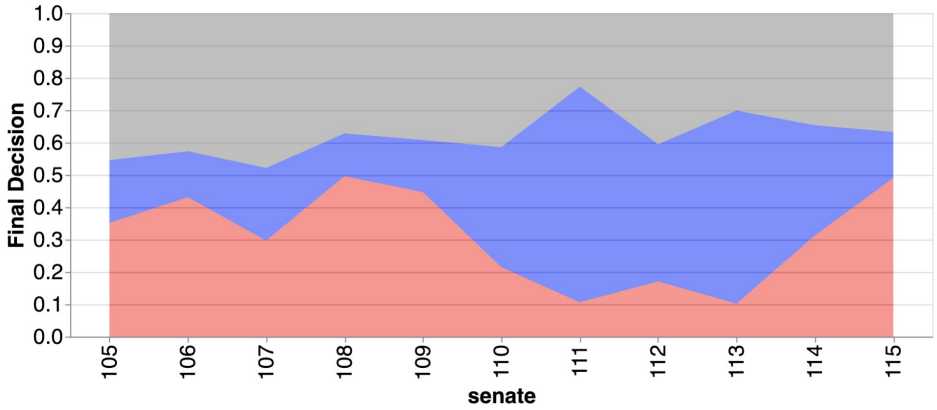
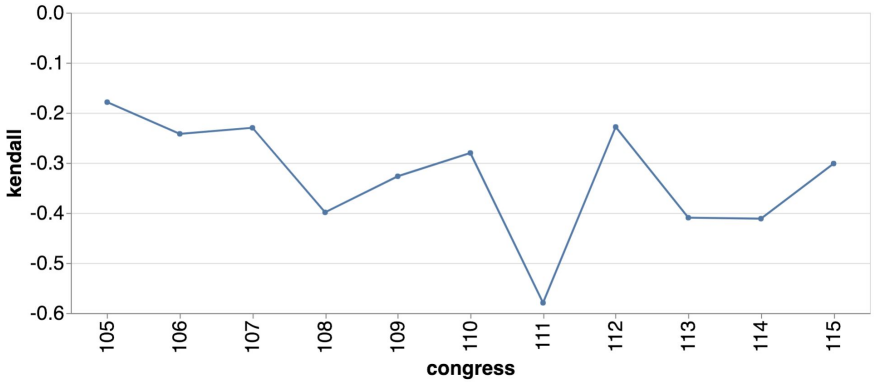


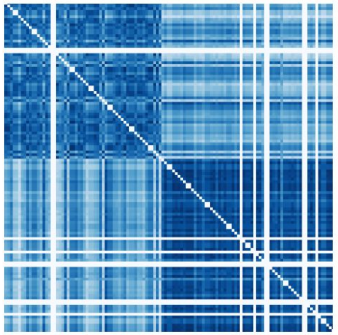



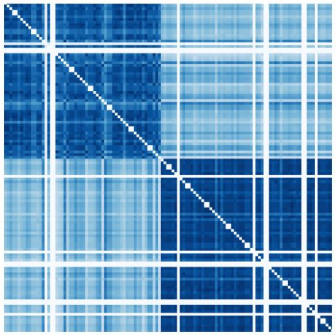
# 115th Senate

105 senators (55 Republicans, 48 Democrats, 2 independent)

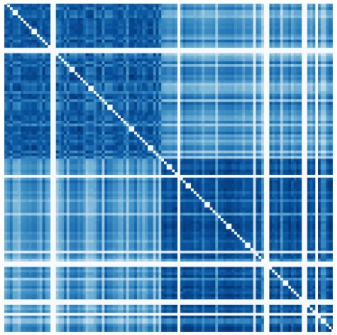
1sem2017 ~ 63 votes



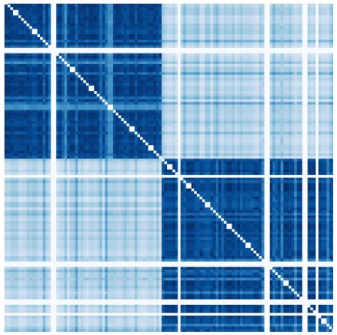
2sem2017 ~ 80 votes



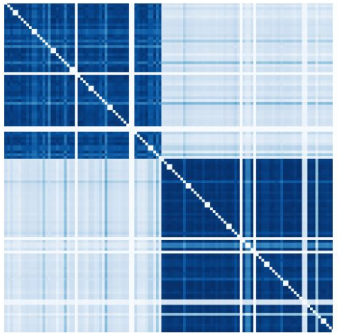
3sem2017 ~ 75 votes



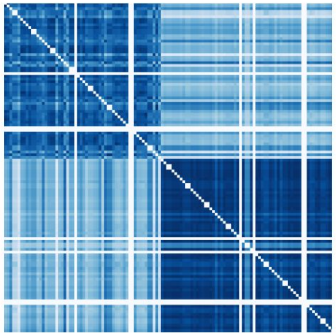
4sem2017 ~ 56 votes



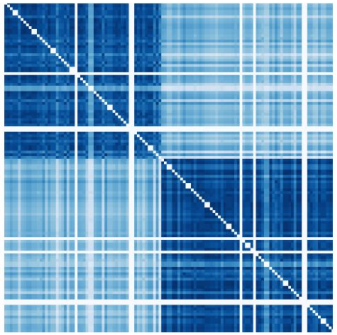
1sem2018 ~ 101 votes



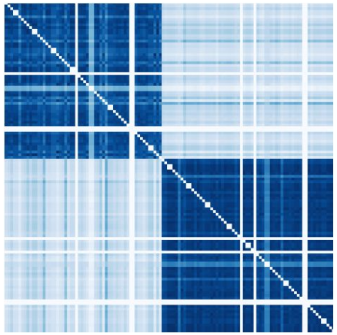
2sem2018 ~ 54 votes



3sem2018 ~ 53 votes



4sem2018 ~ 117 votes

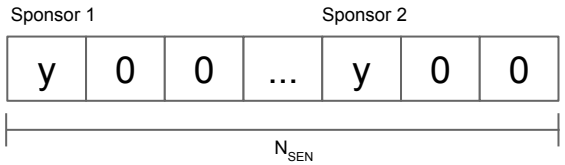


# Sponsorship Profile

Over the 115th Senate, 79 bills were sponsored by senators (63 Republicans, 8 Democrats and 8 independent).

Most bills were from the Budget Committee or Foreign Relations Committee.

The sponsorship profile vector for a given vote is represented by the sponsors' final votes in a sparse vector:

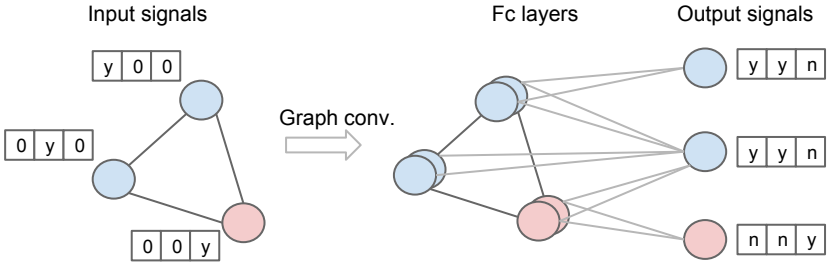


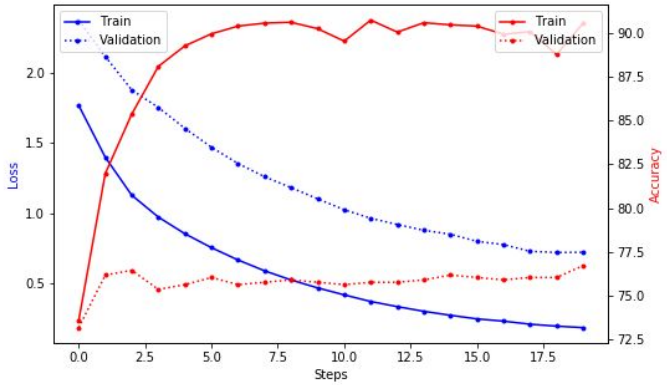

Data per Senate:

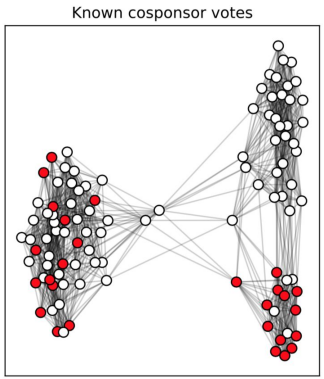
| Senate | 105 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 |
|---|---|---|---|---|---|---|---|---|---|---|
| Bills | 59 | 40 | 48 | 326 | 277 | 156 | 262 | 193 | 258 | 79 |

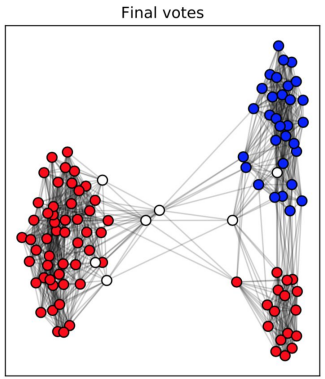
# Convolutional Neural Networks Model

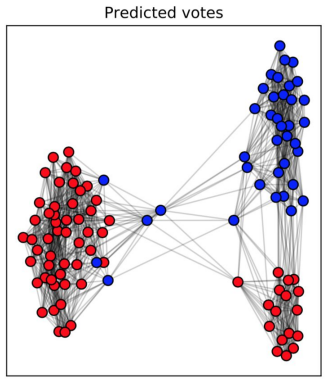
- Input: sponsorship profile for each bill ($N_{BILLS}$ x $N_{SEN}$) + graph laplacian
- Output: senators' voting position for each bill ($N_{BILLS}$ x $N_{SEN}$)
- Data split: train (50%), validation (10%), test (40%).



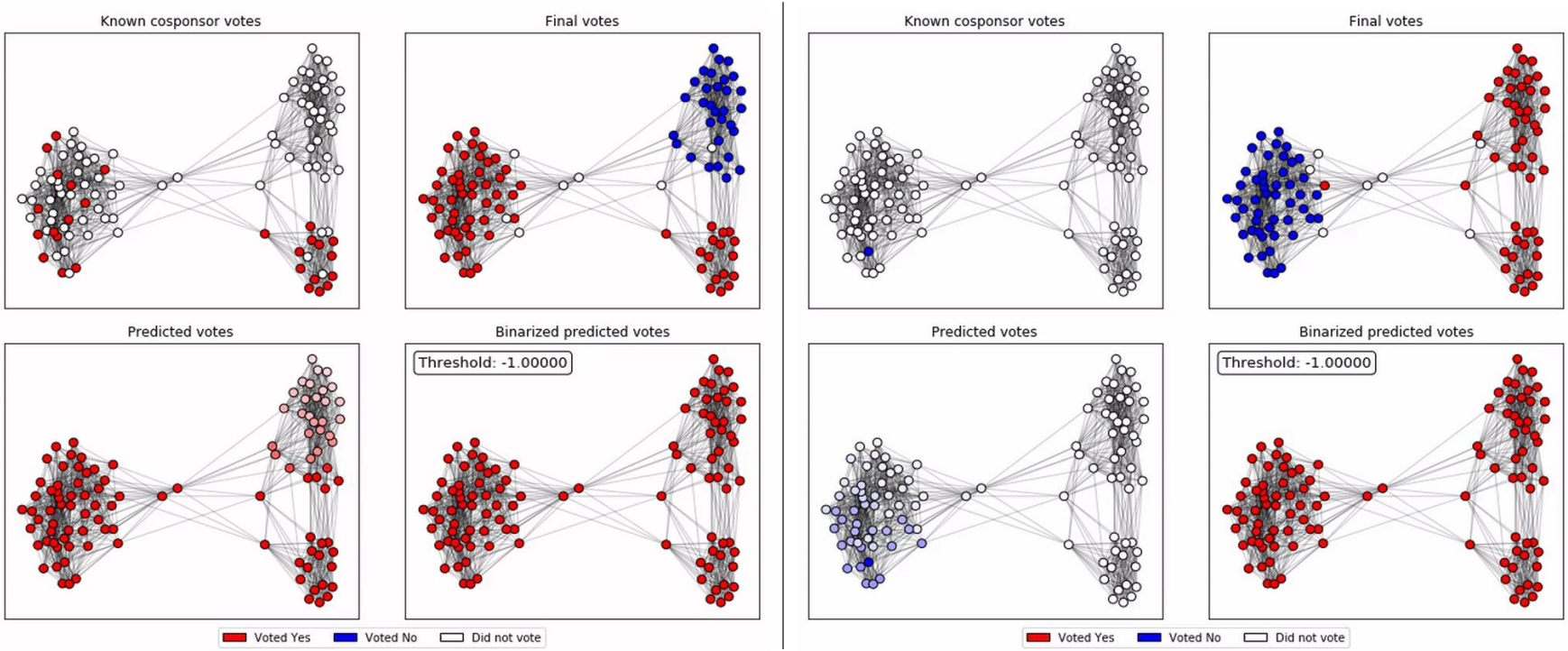




# Transductive Learning

- Inputs are known cosponsor positions
- Infer all other senators by variation minimization



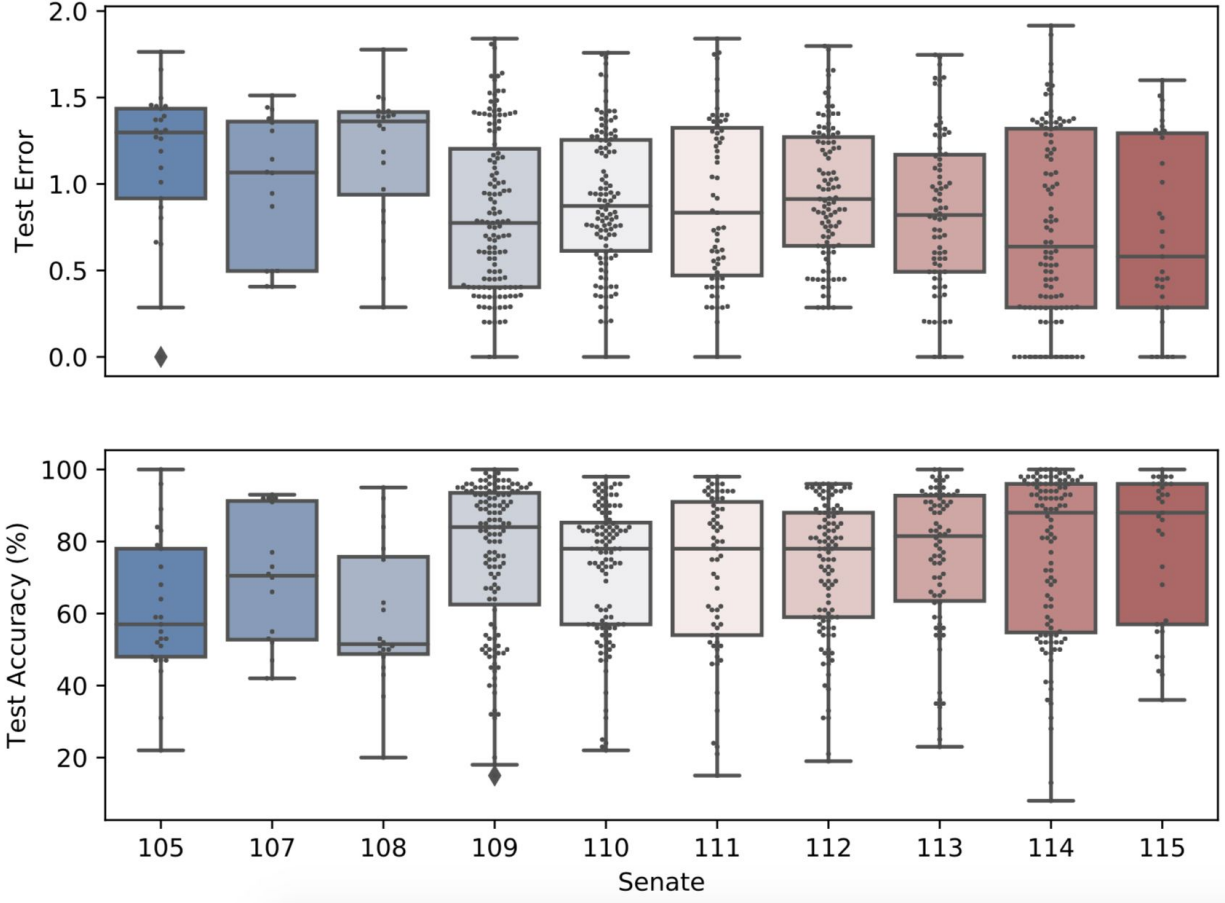
# Transductive Learning

- Predict threshold *t* using Random Forest
- Features are cosponsor statistics
- Targets are best thresholds

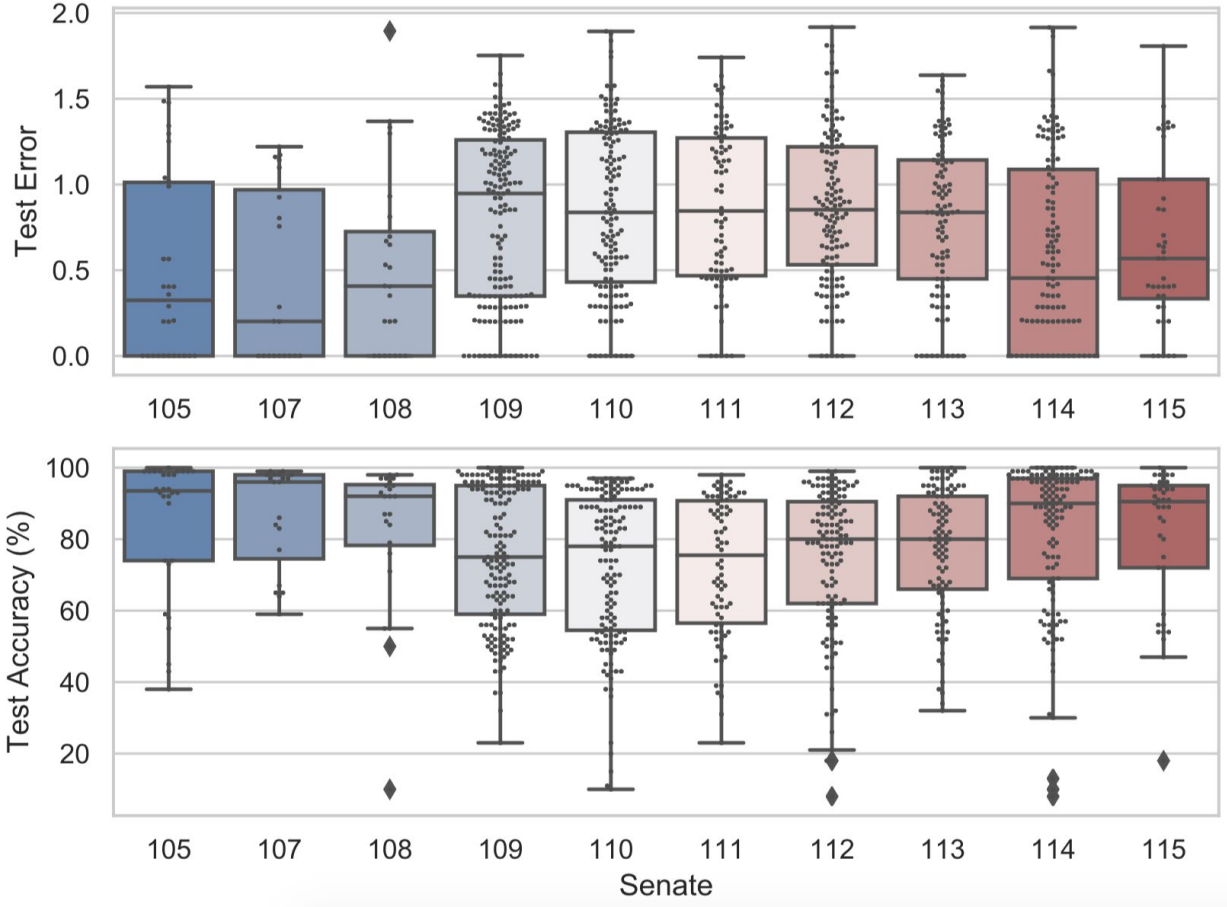
Random forest training data example:

| # Dem Yea | # Dem Nay | # Rep Yea | # Rep Nay | # Dem = 0 | # Rep = 0 | # Dem > # Rep | *t* |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 25 | 0 | True | False | False | 0.231 |
| 13 | 0 | 14 | 0 | False | False | False | 0.993 |
| 0 | 0 | 0 | 1 | False | False | False | -0.051 |
| 42 | 0 | 0 | 0 | False | True | True | 0.249 |

# Results: Graph CNN



# Results: Transductive Learning



# Conclusion and further enhancements

- Exploratory data analysis: Senate polarization and majority / minority behavior
- Two methods for predicting voting pattern:
  - Transductive learning achieved the highest accuracy scores (avg. 86%)
  - Graph CNN did better with more data and much worse with less
- Apply learning methods to a multipartisan scenario
- Extend the analysis to House of Representatives