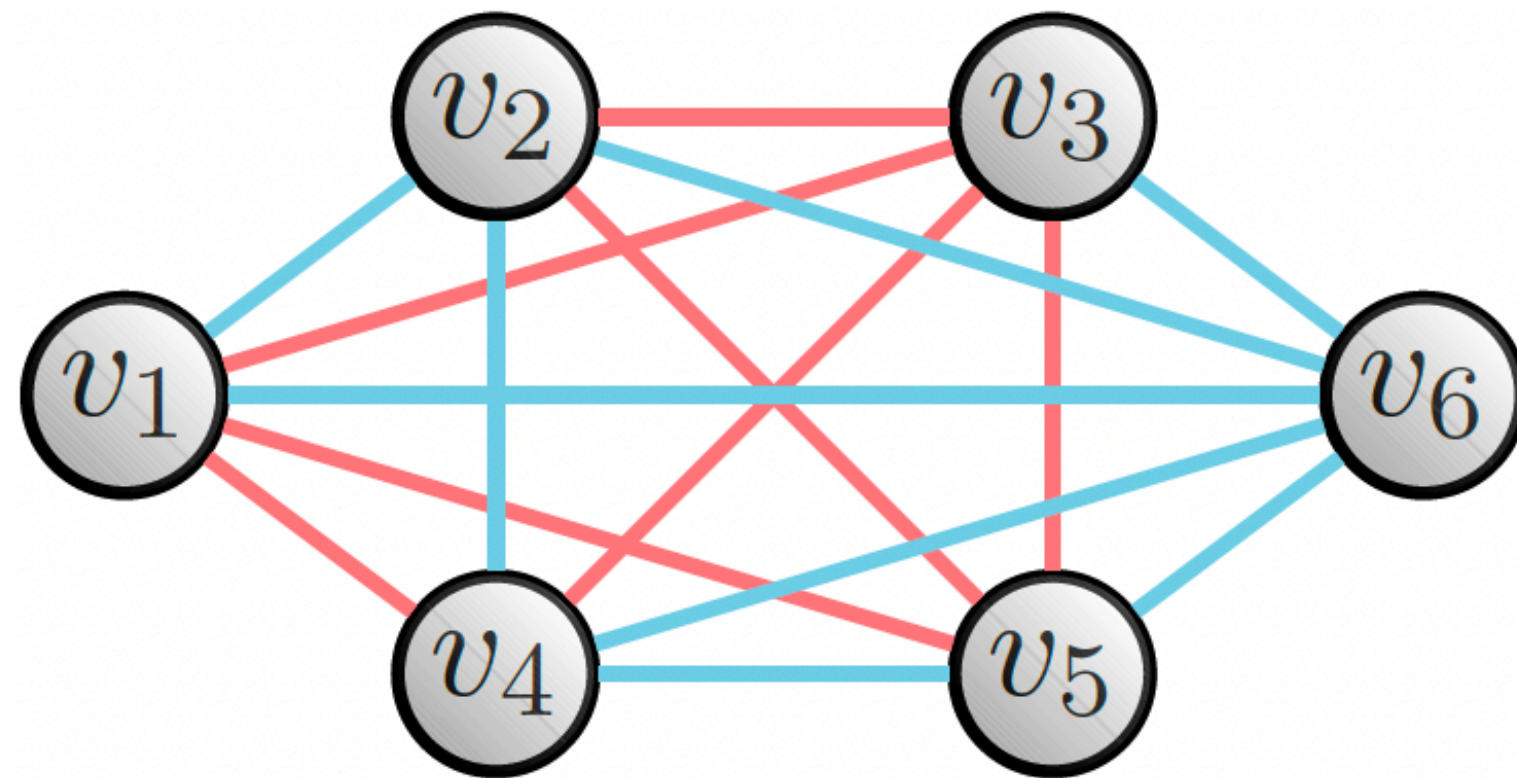# Kick-off Meeting
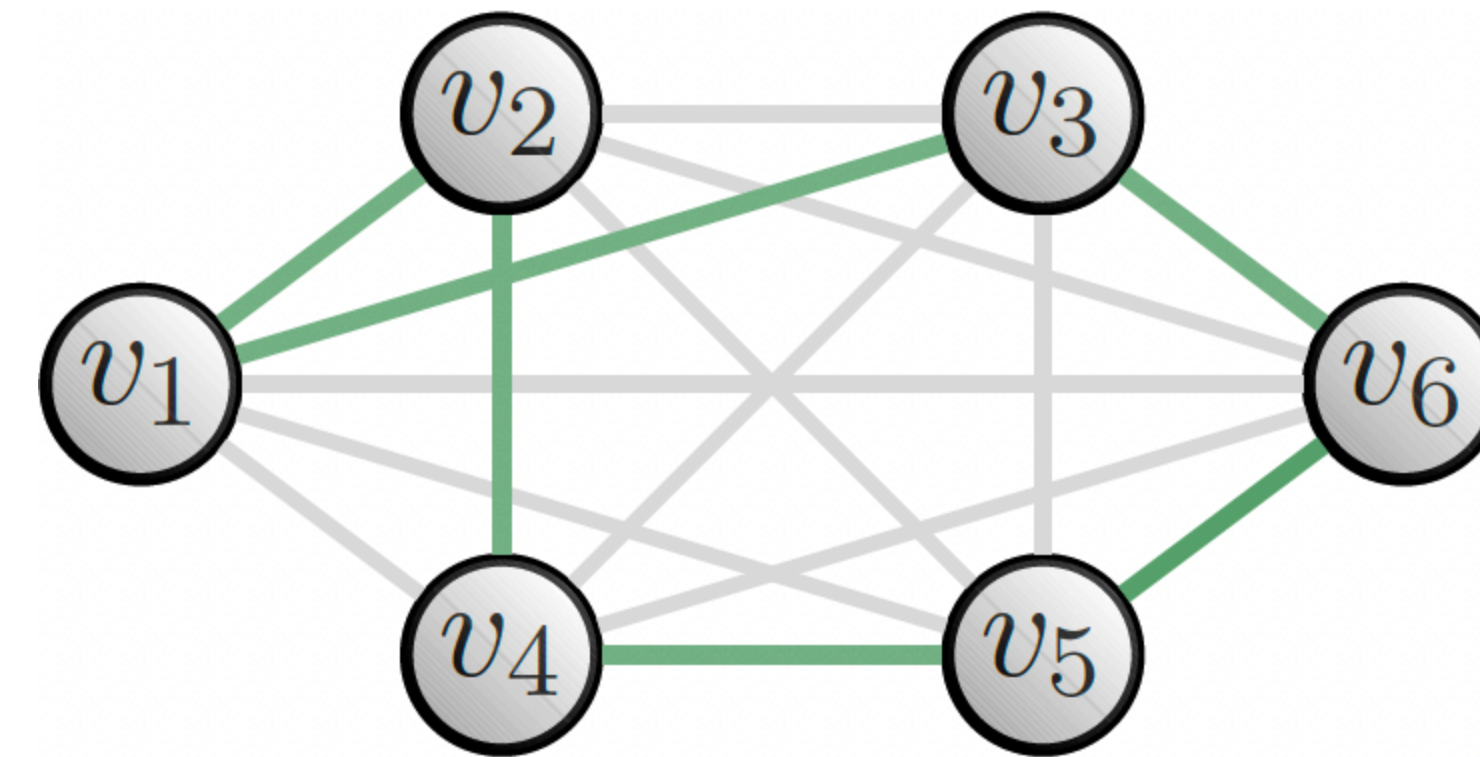
Machine Learning for Combinatorial Optimization

Seminar (Master): WS 22/23, Christopher Morris, RWTH Aachen University

Combinatorial Optimization

Example: Traveling Saleperson Problem

Problem instance

Optimal solution

Definition: Traveling Salesperson Problem (TSP)

Input: Assume a complete graph $G = (V(G), E(G))$ with edge costs $w \colon E(G) \to \mathbb{R}$.

Output: A permutation of the nodes $\sigma \colon \{0, \ldots, n-1\} \to V(G)$ such that

$$\sum_{i=0}^{n-1} w((\sigma(i), \sigma((i+1) \mod n))$$

is minimal over all permutations, where $n = |V|$.

Combinatorial Optimization

Example: Traveling Saleperson Problem

In the last 70 years, substantial research using…

- Integer linear programming,

- Constraint satisfaction programming,

- Approximation algorithms,

- Local search and other heuristics,

- …

Combinatorial Optimization and Machine Learning

Example: Traveling Saleperson Problem

Limitations of current approaches

Above approaches solves each instance *in isolation*. However, often similar instances have to be solved *repeatedly*.

In recent years, machine learning has been used to...

- enhance exact solvers, e.g., for ILPs,

- learn heuristics,

- learn to select algorithms,

- ...

Seminar Organization

Overview and requirements for passing

You will get a paper assigned, and have to...

- Give a 30-minute-long talk about your assigned paper

- Write a 12- to 15-page detailed report about your assigned paper, using the LaTeX template.

- Peer-review your fellow students' reports.

- Attend all meetings and actively participate.

- Plagiarism leads to failing the seminar.

Seminar Organization

Talks

Aim of your talk is to...

- Give a 30-minute polished presentation about your assigned paper, i.e.,

  - You should provide an overview of your assigned paper.

  - Highlight most important concepts and ideas.

  - If possible explore one key concept in more detail.

  - The target audience are your fellow students.

  - Strive for clarity. Make your talk as understandable as possible, strive for a mix of formal correctness and intuition.

Seminar Organization

Reports

Aim of your report is to...

- Give a detailed overview of the assigned paper.

- 12 to 15 pages, using the provided LaTeX template.

- Strive for clarity and formal correctness.

Seminar Organization

Peer review of reports

You get one report assigned from your fellow student…

- Annotate the PDF with corrections, comments, and suggestions and improvements.

- Additionally submit a half-page report, reporting on the quality of the report and summarize suggested changes and comments.

- Aim is to help your fellow student improve his or her manuscript.

Seminar Organization

Time line and dates

- 10.11.2022, 24:00: Submission of report drafts

- 01.12.2022, 24:00: Submission of reports for peer review

- 14.12.2022, 24:00: Submission of peer reviews

- 20.12.2022, 10:00: In person meeting, discussion of peer reviews

- 09.01.2023, 24:00: Submission of revised reports

- 16.01.2023, 24:00: Feedback by the organizers

- 31.01.2023, 24:00: Submission of final reports

- 15.02.2023, 24:00: Submission of presentation slides

- 23.02.2023, 10:00: Talks

Seminar Organization

Papers

1. One Model, Any CSP: Graph Neural Networks as Fast Global Search Heuristics for Constraint Satisfaction

2. Exact Combinatorial Optimization with Graph Convolutional Neural Networks

3. MIP-GNN: A Data-Driven Framework for Guiding Combinatorial Solvers

4. Learning Combinatorial Optimization Algorithms over Graphs

5. Learning To Cut By Looking Ahead: Cutting Plane Selection via Imitation Learning

6. Erdös Goes Neural: An Unsupervised Learning Framework for Combinatorial Optimization on Graphs