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A Graph Neural Network Approach for Solving Assignment Problems in Multi-Object Tracking

Assignment Problem in MOT

Considered Problem

- Exponential growth of number of hypotheses in GLMB filter update
- Truncation using the k-ranked assignment problem

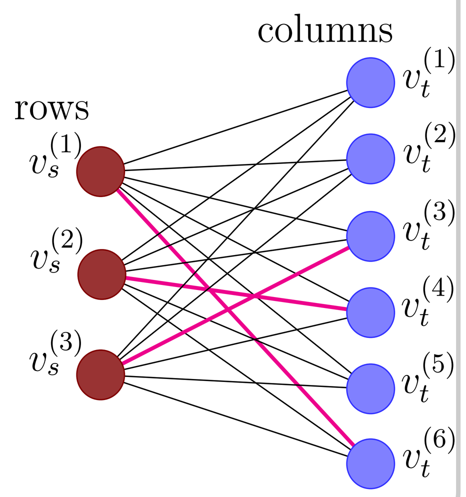
Ranked Assignment Problem

- Cost matrix for possible associations of measurements with tracks [1]

$$C_Z = \Bigg[\underbrace{\begin{matrix} c_{11} & \cdots & c_{1|Z|} \\ & \ddots & \\ \vdots & c_{ij} & \vdots \\ & \ddots & \\ c_{|I|1} & \cdots & c_{|I||Z|} \end{matrix}}_{\text{detected}} \; \underbrace{\begin{matrix} c_1 & \infty & \cdots & \infty \\ \infty & c_2 & \ddots & \\ \vdots & \ddots & \ddots & \vdots \\ & & c_{|I|-1} & \infty \\ \infty & \cdots & \infty & c_{|I|} \end{matrix}}_{\text{misdetected}}\Bigg]$$

- Graph representation of cost matrix as bipartite graph $\mathcal{G} = \{\mathcal{V}_s, \mathcal{V}_t, \mathcal{E}\}$

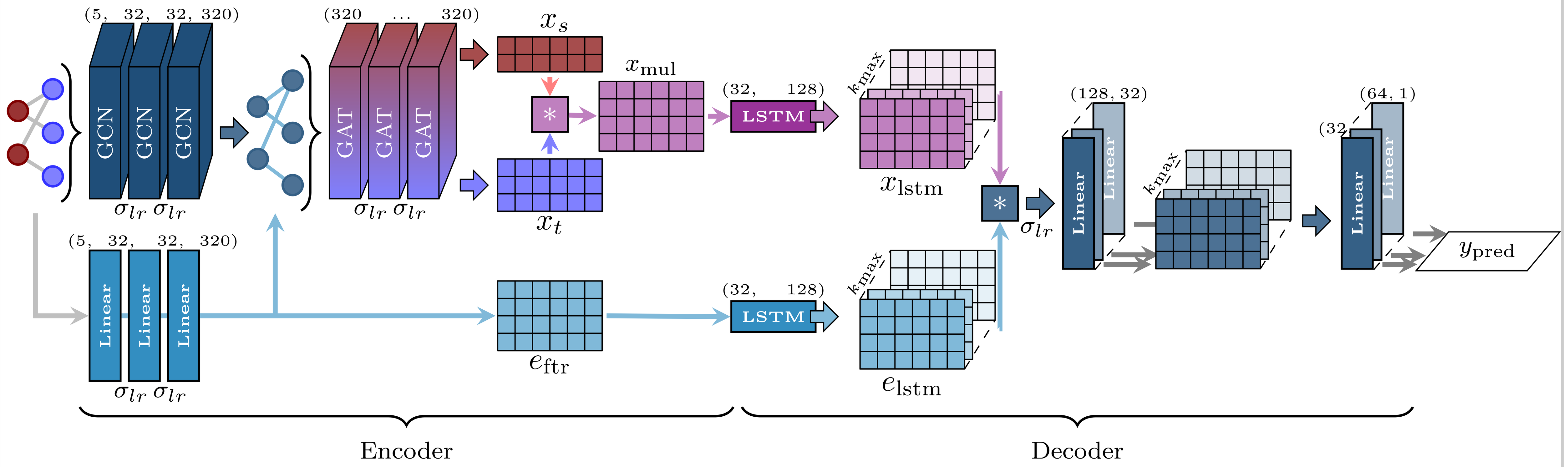
$$C_{ex} = \begin{bmatrix} 27 & 11 & 9 & 9 & 5 & 1 \\ 26 & 6 & 5 & 4 & 5 & 8 \\ 24 & 2 & 1 & 9 & 9 & 7 \end{bmatrix}$$



Proposed Method

Ranked Assignment Prediction Graph Neural Network (RAPNet)

- Architecture consisting of graph creation, RAPNet and post-processing module
- Node feature extraction using ratio of non-∞ values to length of line or column and aggregations *min*, *max*, *mean* and *l2-norm*
- RAPNet architecture



- Greedy post-processing to exploit imperfect output

Training Setup

- 2 datasets: (i) from simulation [2] and (ii) synthetic matrices with selectable parameters (size ν_s and assignments number k_{max}) and random cost values
- 20 epochs with AdamW ($\lambda = 1e^{-3}$), cosine annealing scheduler ($\gamma \in [1e^{-3}, 1e^{-4}]$)
- Novel *wp*-score:

$$wp = \sum_{i=1}^{k} w_i \kappa_i \ , \quad \text{with}$$

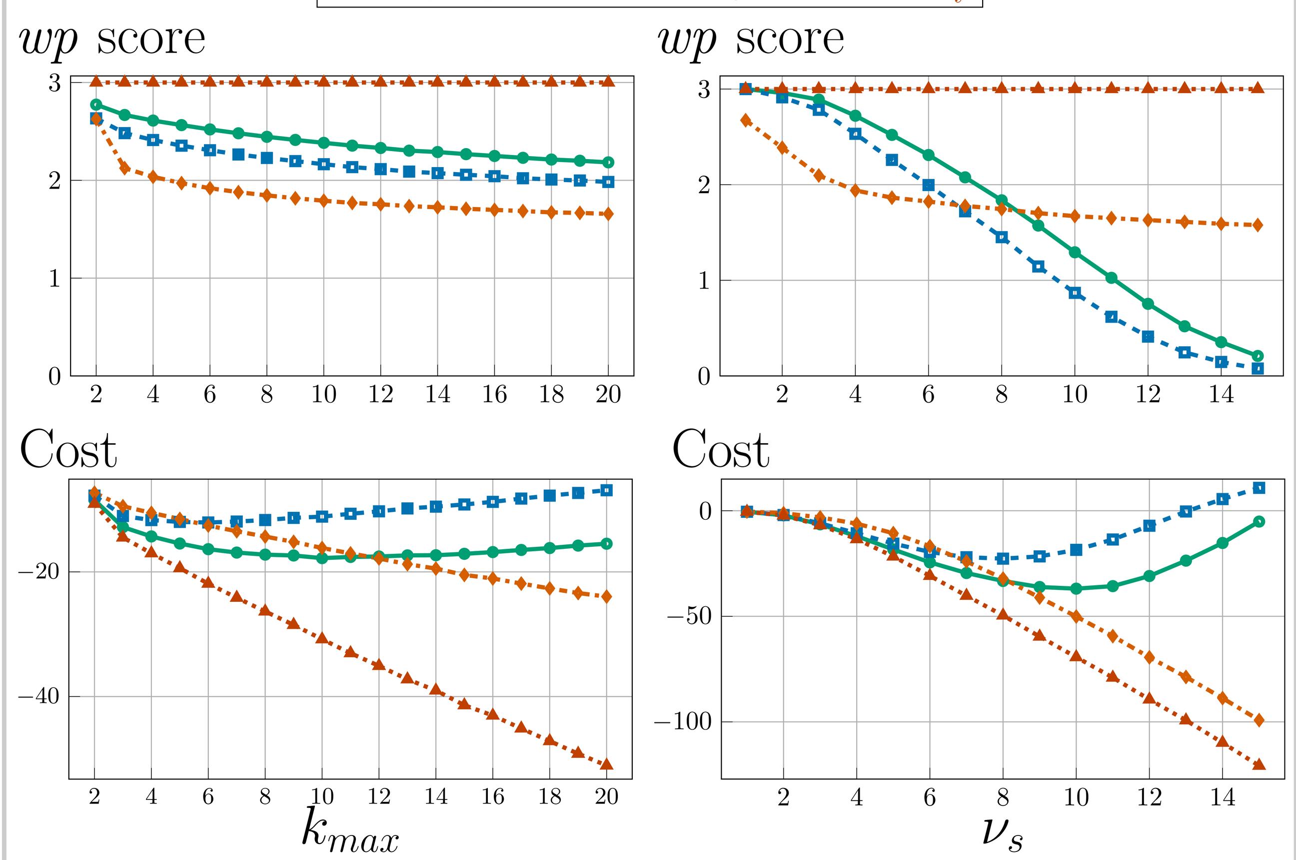
$$\kappa_i \in \{3, 2, 1, 0\} \ , \ w_i = \frac{2 \cdot (k + 1 - i)}{k \cdot (k + 1)}$$

Results

Evaluation

- Baselines: Murty's algorithm [3] and Gibbs sampler [1]
- Comparison of RAPNet alone (ours) and with post-processing (ours-PP)

Parameter Sweeps



Simulation Data Only

Framework	Accuracies $i = 1$	$i = 2$	$i = 3$	$i = 4$	*wp*	Cost
RAPNet-a	0.99	0.91	0.73	0.54	2.74	5.68
RAPNet-PP	0.99	**0.95**	**0.82**	**0.66**	**2.80**	**3.23**
Gibbs	**1**	0.18	0.06	0.04	2.11	14.10

References

[1] B.-N. Vo, B.-T. Vo, and H. G. Hoang, "An Efficient Implementation of the Generalized Labeled Multi-Bernoulli Filter," *IEEE Trans. on Sig. Proc.*, vol. 65, no. 8, pp. 1975–1987, 2017.

[2] M. Herrmann, C. Hermann, and M. Buchholz, "Distributed Implementation of the Centralized Generalized Labeled Multi-Bernoulli Filter," *IEEE Transactions on Signal Processing*, vol. 69, pp. 5159–5174, 2021.

[3] K. G. Murty, "Letter to the Editor - An Algorithm for Ranking all the Assignments in Order of Increasing Cost," Operations Research, vol. 16, no. 3, pp. 682–687, 1968.

Acknowledgement

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