Tracking Space-Filling Features by Two-Step Optimization

Andrea Schnorr, Sebastian Freitag, Torsten W. Kuhlen, Bernd Hentschel
Visual Computing Institute, RWTH Aachen University, Germany
JARA – High-Performance Computing, Germany

1 Introduction

Feature tracking is a key technique for gaining insight into the temporal evolution of objects in time-varying data sets. In order to track space-filling structures, we determine the assignment between features of successive time steps by a two-step, global optimization scheme. First, a *maximum-weight, maximal matching* is computed to provide one-to-one assignments. Second, events are detected in a subsequent step. To this end, we compute an *independent set on a graph representing conflicting event explanations*.

2 Challenges

- Existing approaches, e.g., [1], assume that features cover only a small fraction of the data domain
- These approaches suffer from two issues while tracking space-filling features:
  - The number of possible candidates overlapping with a feature grows significantly
  - Greedily chosen assignments might preclude globally optimal event explanations

3 Method – Two-Step Optimization

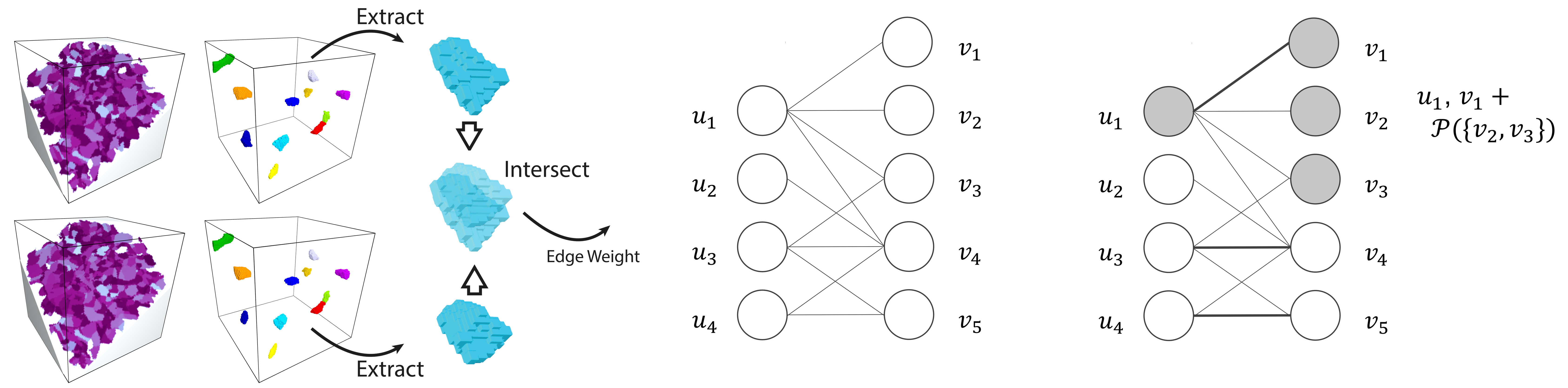

Fig. 1: Matching step: a weighted bi-partite graph is constructed that contains one node per object connected via edges encoding similarity (left to middle). A maximum-weight, maximal matching is computed providing one-to-one assignments (bold edges) between features of consecutive time steps (right). A detailed description of this step can be found in [2].

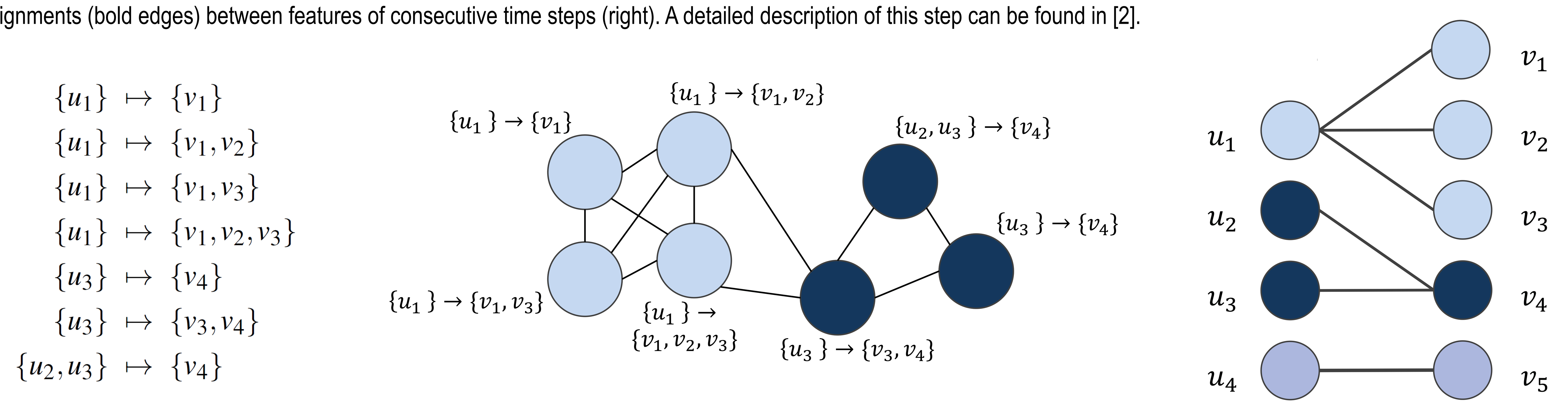

Fig. 2: Event detection: all possible events are enumerated based on the matching result. To this end, the power set of all possible candidates is constructed and every subset combined with the matching edge is stored as event explanation (left). A second graph is constructed that contains a node with corresponding weight for every explanation and edges between conflicting nodes (middle). A maximum weight independent set of this graph provides the resulting events in the bi-partite graph (right).

4 Discussion

- Independent set problem is NP-hard in general
- Matching step reduces problem to tractable size:

Matching	on	off	off	off
Max. candidates	-	5	6	7
Nodes	6.009	177.867	270.347	394.507
Edges	219.756	19.755.450	61.597.990	173.486.819

5 Conclusion

- Approach can be applied to spatially sparse features as well
- Event detection is usable without matching step for spatially sparse features
- All possible events are enumerated and best solution is chosen by maximum weight independent set
- Result contains events with an average overlap of ~ 80%

Acknowledgements

The authors wish to acknowledge funding by the German Research Foundation DFG under grant KU 1132/10-1.

References

[1] Silver D., Wang X.: Tracking and Visualizing Turbulent 3D Features, IEEE TVCG 3, 2 (1997), 129-141.
[2] Schnorr A., Goebbert J.-H., Kuhlen T. W., Hentschel B.: Tracking Space-Filling Structures in Turbulent Flows. Proceedings of the IEEE Symposium on LDAV (2015), pp. 143-144.