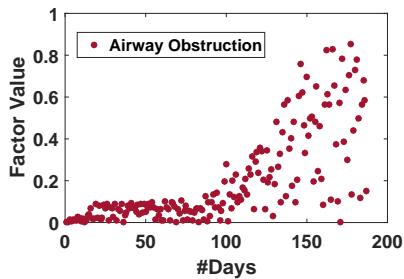


**Figure 5:** Scalability analysis of  $C^3$  APTION method using synthetic and three real world datasets. (a-b): Scalability analysis of synthetic data with respect to varying number of users  $K$ , where  $K$  ranges  $10^3 - 10^6$ . Stable performance (RMSE) in the range  $1K - 50K$ , for most methods. Baseline method SCD and RCTF runs out of memory. (c-d): Scalability analysis with respect to Movielens dataset (c-d), Adobe dataset (e-f) and CMS health record data (g-h).  $C^3$  APTION-ALS significantly outperforms the other methods even when data is very sparse.



**Figure 6:** Visualization of time-frame captured of the patient no. 11426 created by  $C^3$  APTION-ALS on CMS dataset.

[7] Riccardo Bellazzi, Marianna Diomidous, Indra Neil Sarkar, Katsuhiko Takabayashi, Andreas Ziegler, and Alexa T McCray. Data analysis and data mining: current issues in biomedical informatics. *Methods of information in medicine*, 50(6):536, 2011.

[8] Rasmus Bro and Henk AL Kiers. A new efficient method for determining the number of components in parafac models. *Journal of Chemometrics: A Journal of the Chemometrics Society*, 17(5):274–286, 2003.

[9] J Douglas Carroll and Jih-Jie Chang. Analysis of individual differences in multidimensional scaling via an n-way generalization of “eckart-young” decomposition. *Psychometrika*, 35(3):283–319, 1970.

[10] Christos Chatzichristos, Mike Davies, Javier Escudero, Eleftherios Kofidis, and Sergios Theodoridis. Fusion of eeg and fmri via soft coupled tensor decompositions. In *2018 26th EUSIPCO*, pages 56–60. IEEE, 2018.

[11] CMS. Data. <https://www.cms.gov/Research-Statistics-Data-and-Systems/Downloadable-Public-Use-Files/SynPUFs>, 2008. [Online].

[12] Georgios Theocharous ekta Gujral and Evangelos E. Papalexakis. Constrained coupled cp and parafac2 tensor decomposition. 2020.

[13] Matthieu Genicot, P-A Absil, Renaud Lambiotte, and Saber Sami. Coupled tensor decomposition: a step towards robust components. In *2016 24th EUSIPCO*, pages 1308–1312. IEEE, 2016.

[14] Ekta Gujral and Evangelos E Papalexakis. Smacd: semi-supervised multi-aspect community detection. In *Proceedings of the 2018 SIAM SDM*, pages 702–710. SIAM, 2018.

[15] Ekta Gujral, Ravdeep Pasricha, and Evangelos Papalexakis. Beyond rank-1: Discovering rich community structure in multi-aspect graphs. In *Proceedings of The Web Conference 2020*, 2020.

[16] F Maxwell Harper and Joseph A Konstan. The movielens datasets: History and context. *Acm transactions on interactive intelligent systems*, 5:19, 2016.

[17] R.A. Harshman. Foundations of the parafac procedure: Models and conditions for an “ explanatory” multimodal factor analysis. 1970.

[18] Richard A Harshman. Parafac2: Mathematical and technical notes. *UCLA working papers in phonetics*, 22(3044):122215, 1972.

[19] ByungSoo Jeon, Inah Jeon, Lee Sael, and U Kang. Scout: Scalable coupled matrix-tensor factorization-algorithm and discoveries. In *2016 IEEE 32nd International Conference on Data Engineering (ICDE)*, pages 811–822. IEEE, 2016.

[20] Hyunsoo Kim and Haesun Park. Nonnegative matrix factorization based on alternating nonnegativity constrained least squares and active set method. *SIAM journal on matrix analysis and applications*, 30(2):713–730, 2008.

[21] Jingu Kim and Haesun Park. Fast nonnegative tensor factorization with an active-set-like method. In *High-Performance Scientific Computing*, pages 311–326. Springer, 2012.

[22] T.G. Kolda and B.W. Bader. Tensor decompositions and applications. *SIAM review*, 51(3), 2009.

[23] Shuangzhe Liu and Götz Trenkler. Hadamard, khatri-rao, kronecker and other matrix products. *International Journal of Information and Systems Sciences*, 4(1):160–177, 2008.

[24] Anant Madabhushi and George Lee. Image analysis and machine learning in digital pathology: Challenges and opportunities, 2016.

[25] Olivera Novović, Sanja Brdar, and Vladimir Crnojević. Evolving connectivity graphs in mobile phone data. In *NetMob, The main conference on the scientific analysis of mobile phone datasets*, pages 73–75, 2017.

[26] Evangelos E Papalexakis. Automatic unsupervised tensor mining with quality assessment. In *Proceedings of the 2016 SIAM Int. Conf. on Data Mining*. SIAM, 2016.

[27] Evangelos E Papalexakis, Tom M Mitchell, Nicholas D Sidiropoulos, Christos Faloutsos, Partha Pratim Talukdar, and Brian Murphy. Scoup-smt: Scalable coupled sparse matrix-tensor factorization. *arXiv preprint arXiv:1302.7043*, 2013.

[28] Tara Safavi, Chandra Sripada, and Danai Koutra. Fast network discovery on sequence data via time-aware hashing. *Knowledge and Information Systems*, 61(2):987–1017, 2019.