Graph Representation and Embedding for Semiconductor Manufacturing Fab States

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Semiconductor Manufacturing requires Planning Algorithms



Semiconductor Manufacturing in the MiniFab







on the basis of a decision by the German Bundest:



Semiconductor Manufacturing requires Planning Algorithms

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Planning algorithms require well-structured input data



How to encode the state of a whole fab to provide it to a planning algorithm?

¹ (Sarin et al. 2011), ² (Li et al. 2013), ³ (Schelthoff et al. 2022), ⁴ (Qiao et al. 2013)

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Modelling a Semiconductor Manufacturing Fab State as a Graph

Graph representation incorporates structure and parameters of the fab state



How does this graph representation approach help to encode fab states?

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Using Representation Learning to Embed Fab State Graphs

Graph embedding allows to encode fab state graph with low-dimensional vector

graph2vec (Narayanan et al. (2017)): Map graphs to vectors

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Extract the subgraphs of each graph 1 **EqpG**_{Diffusio} EqpG_{Lithograp} EqpG_{Diff} Eqp_A Eqp_B Eqp_B Eqp Eqp_E Eqp Eqp_A Eqp_B Eqp_A Op, Route Lot₂ Lot₃ Lot₁ Op_2 Route Lot₁ ... T E A 4Winter Simulation Conference 2022 Graph Representation and Embedding for Semiconductor Manufacturing Fab States



Using Representation Learning to Embed Fab State Graphs

Graph embedding allows to encode fab state graph with low-dimensional vector

graph2vec (Narayanan et al. (2017)): Map graphs to vectors

2 Learn embeddings of graphs based on their subgraphs





From Fab State to Graph Representation to Graph Embedding



Representing and embedding fab states of the MiniFab



How do numerical results look like when applying this approach?







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Graph Embedding of different Fab States of the MiniFab

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Numerical results for two-dimensional embedding space



Setting:

- MiniFab with 3 lots in production
- 1000 different fab states

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Graph Embedding of different Fab States of the MiniFab

Numerical results for two-dimensional embedding space – analysis of embeddings





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Graph Embedding of different Fab States of the MiniFab

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Numerical results for two- and three-dimensional embedding space





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Graph Representation and Embedding of Fab States

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An approach to encode fab states



MiniFab use case indicates that low-dimensional embeddings of fab states preserve some structural information of the original fab state (modelled as a graph).

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Graph Representation and Embedding of Fab States



An approach to encode fab states



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¹² Graph Representation and Embedding for Semiconductor Manufacturing Fab States