Machine Learning Using Quantum Computing

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Outline

- Reinforcement Learning (RL)
- Quantum Hierarchical Rick Parity (QHRP)
- Big Data Visualization tool (BiDViT)
- Signed Graph Clustering (SGC)

Reinforcement Learning (RL)

Reinforcement Learning (RL)

Summary of the research

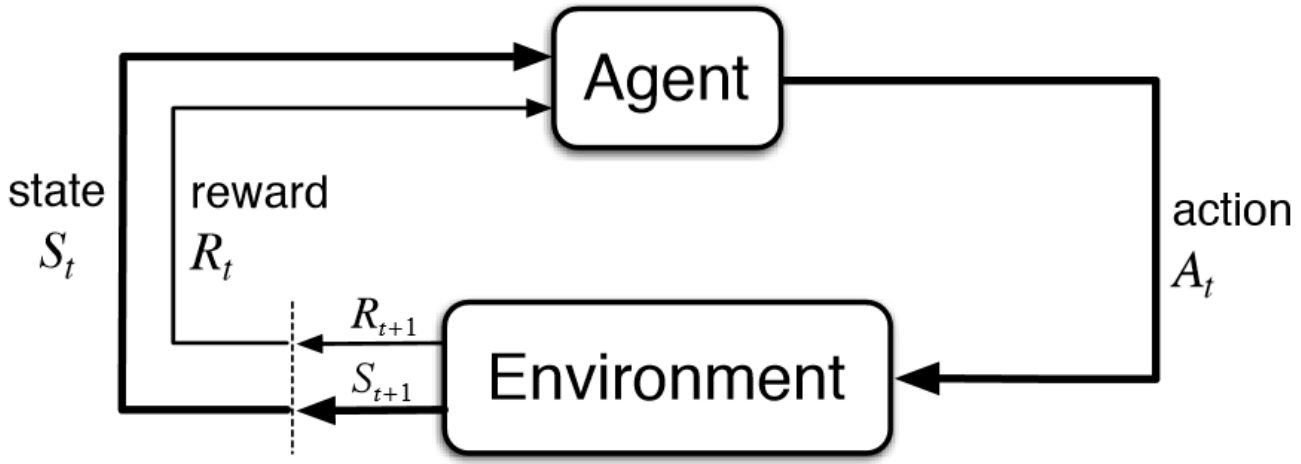
Problem: RL is a challenging task in ML b/c it requires many samples to train a model. Here we use a quantum system to reduce the sample complexity in RL.

Claim: We have devised a RL algorithm with better performance (with respect to the sample complexity) over the traditional approaches.

Reinforcement Learning

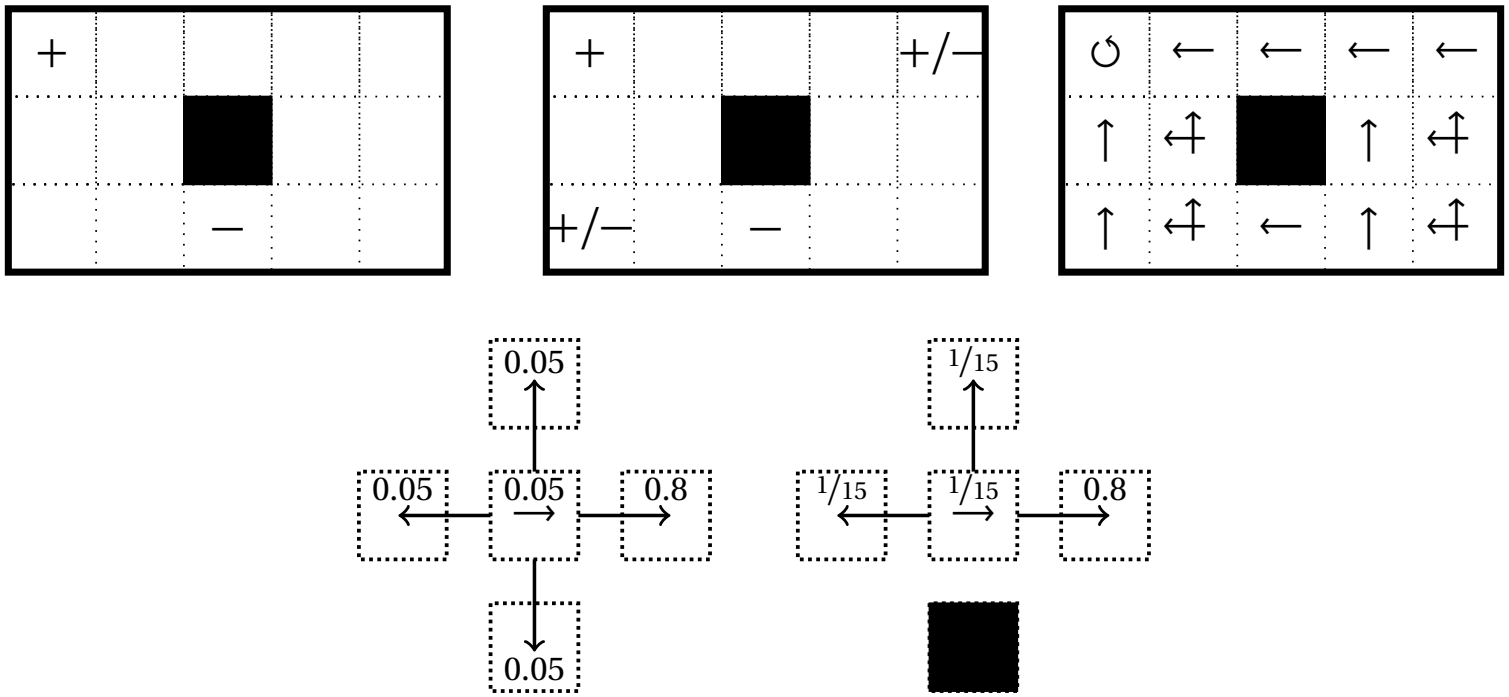
Background

Reinforcement Learning: You play a game whose rules you do not know. After 100 moves or so your opponent announces ‘You lose’. This is RL in nutshell.



Reinforcement learning

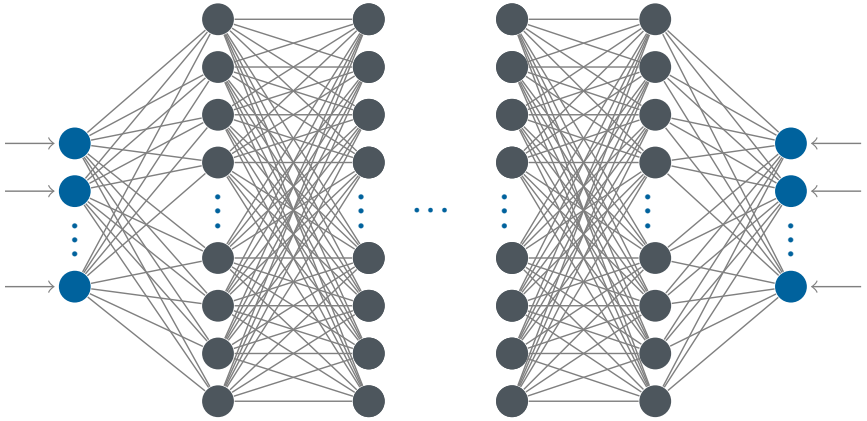
A case study — Grid-world problem



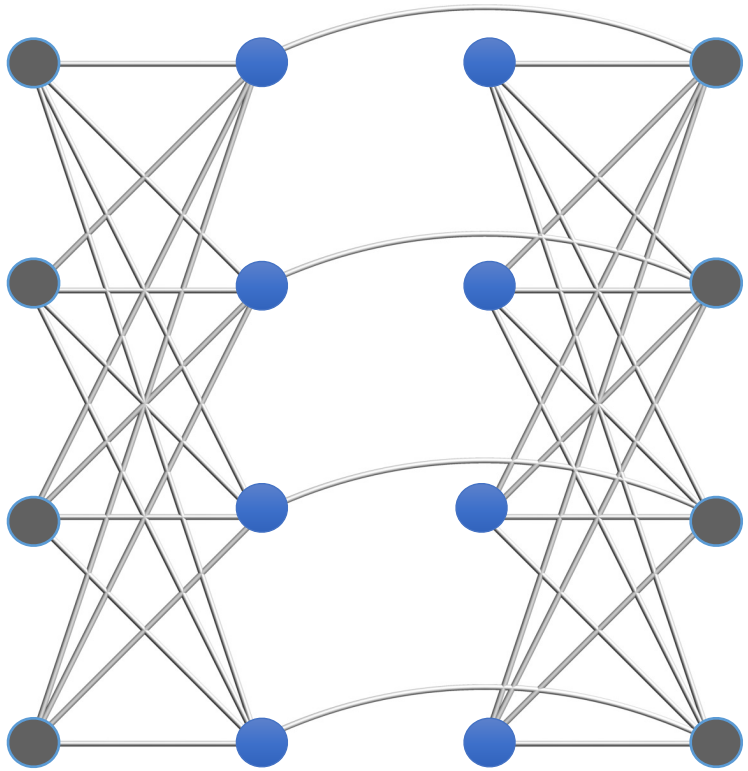
Reinforcement Learning

Model

Deep Boltzmann Machines



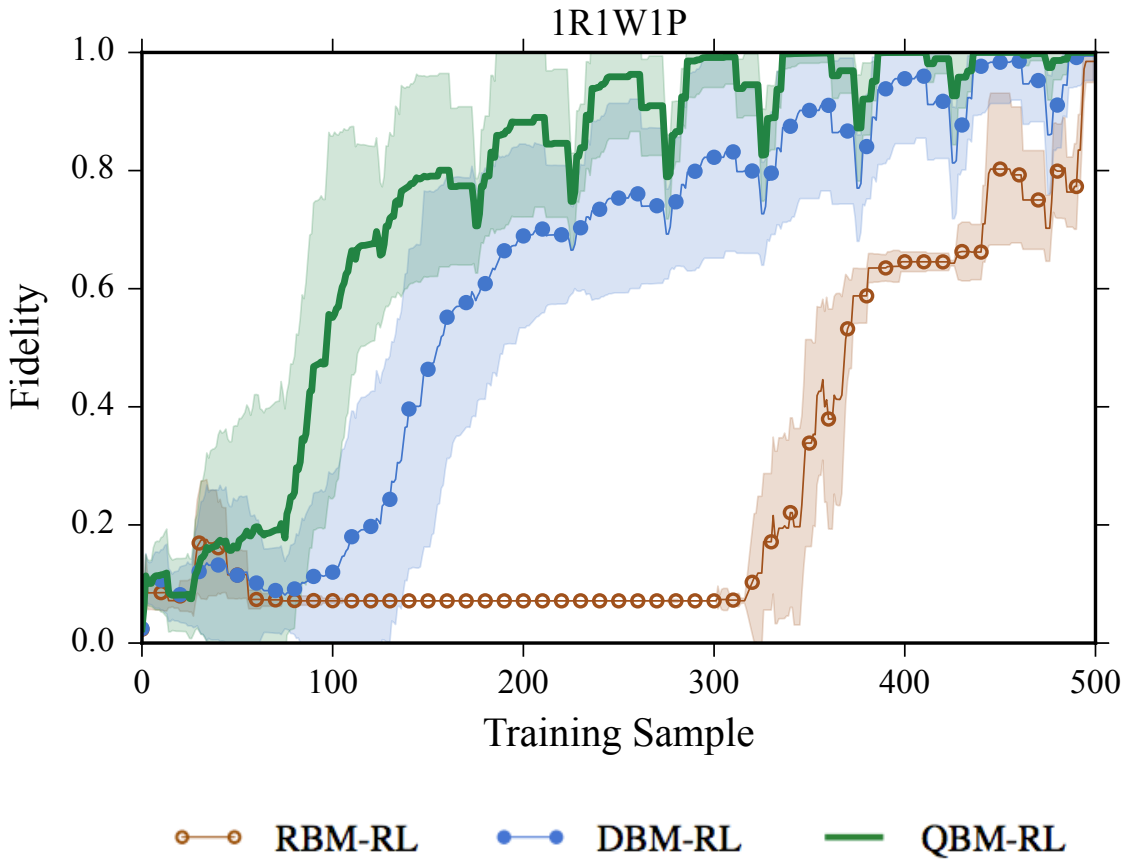
Chimera Graph — DWave

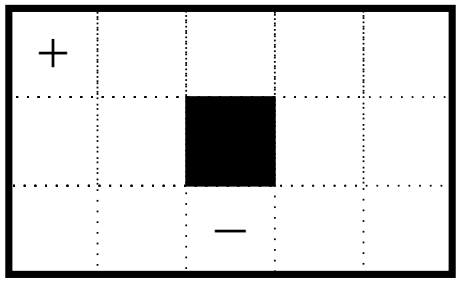


- Visible nodes — states and actions
- Hidden nodes

Reinforcement Learning

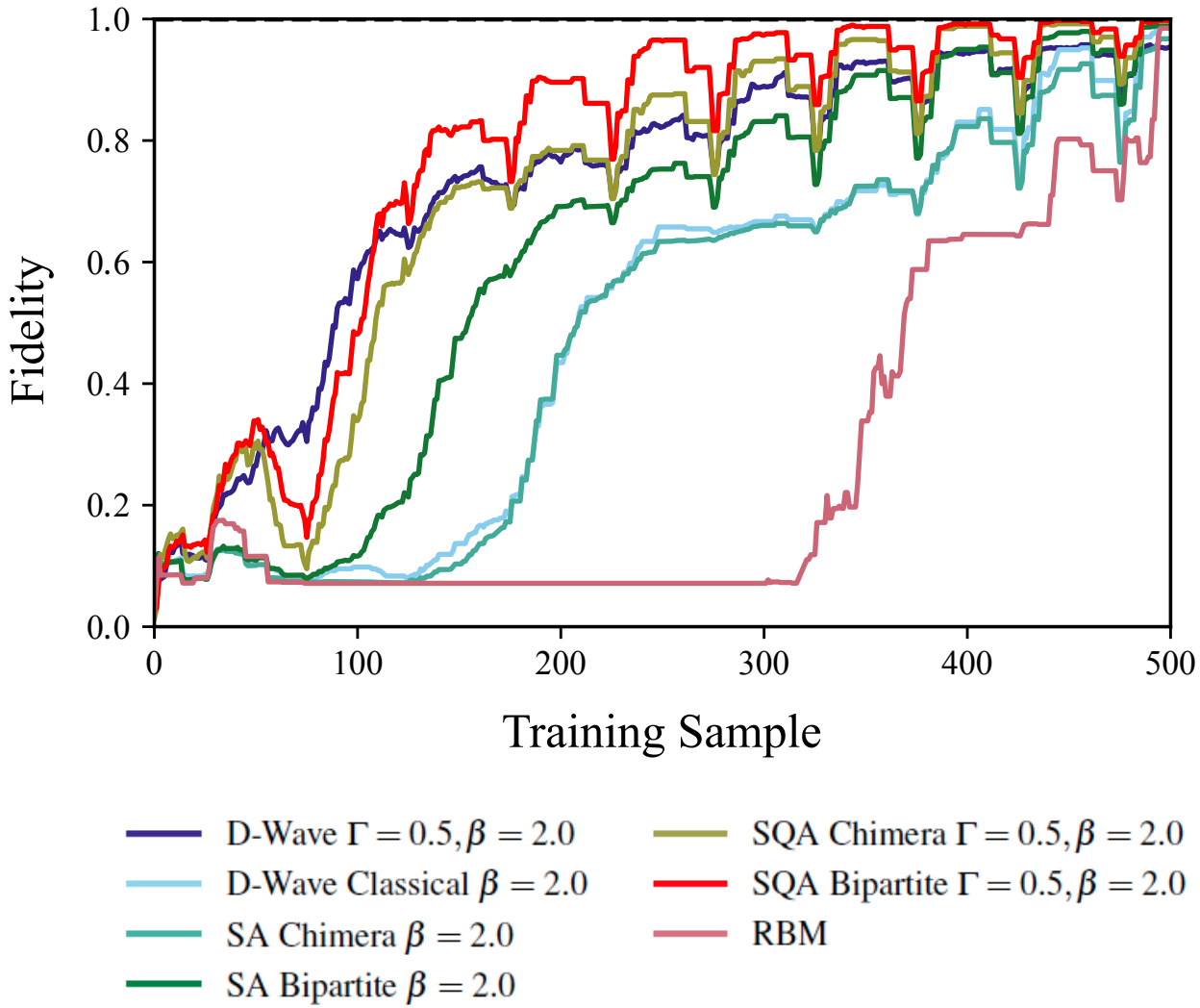
Results





Reinforcement Learning

Results



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Quantum Hierarchical Risk Parity (QHRP)

Quantum-inspired Hierarchical Risk Parity (QHRP)

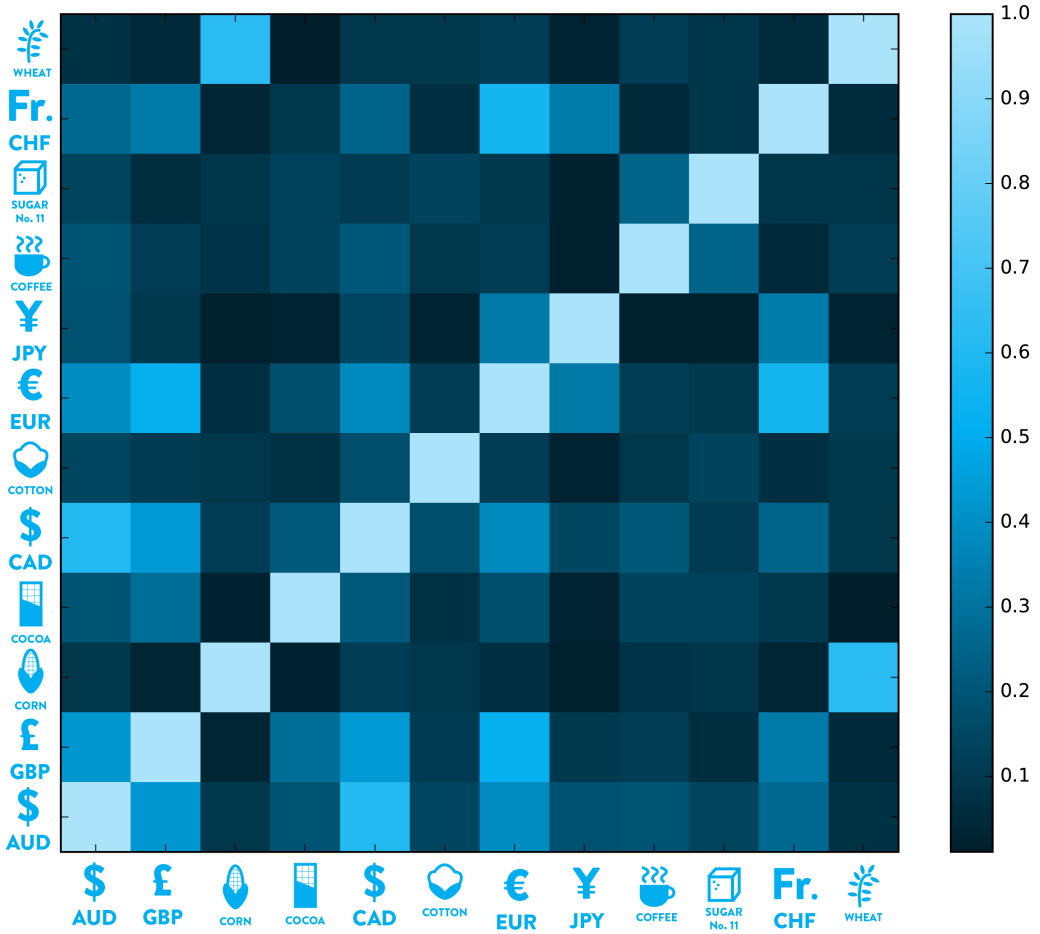
Summary of the research

Problem: In the field of portfolio theory, the main goal is to determine what balance of assets to hold to achieve optimal risk reward balance. We devise a quantum-inspired algorithm for portfolio optimization.

Claim: We have developed a quantum-inspired algorithm for optimizing portfolios . Our method has outperformed conventional methods in terms of a variety of risk measures.

Quantum-inspired Hierarchical Risk Parity

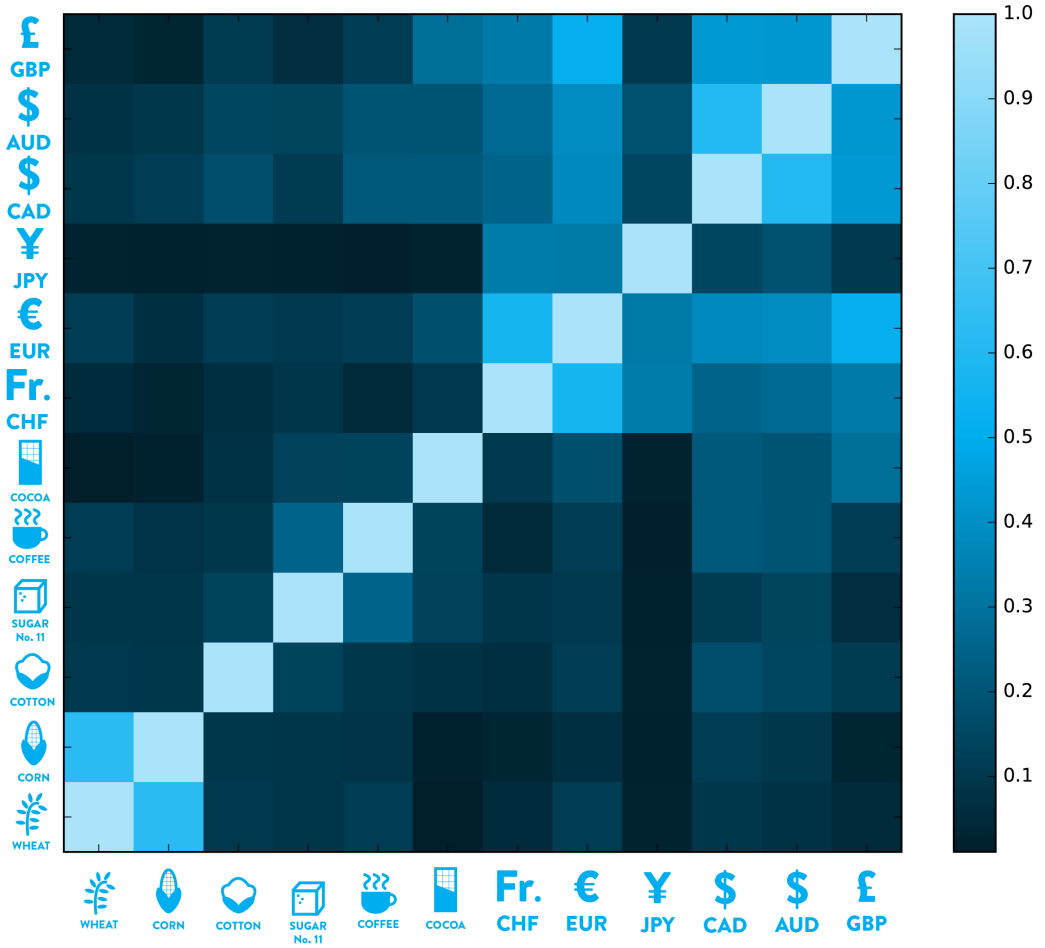
How does QHRP work?



A correlation matrix is created from the daily price changes of each asset.

Quantum-inspired Hierarchical Risk Parity

How does QHRP work?



Reorder the assets so that those with high correlation are close together and those with low correlation are farther apart. The more assets involved, the more difficult this becomes.

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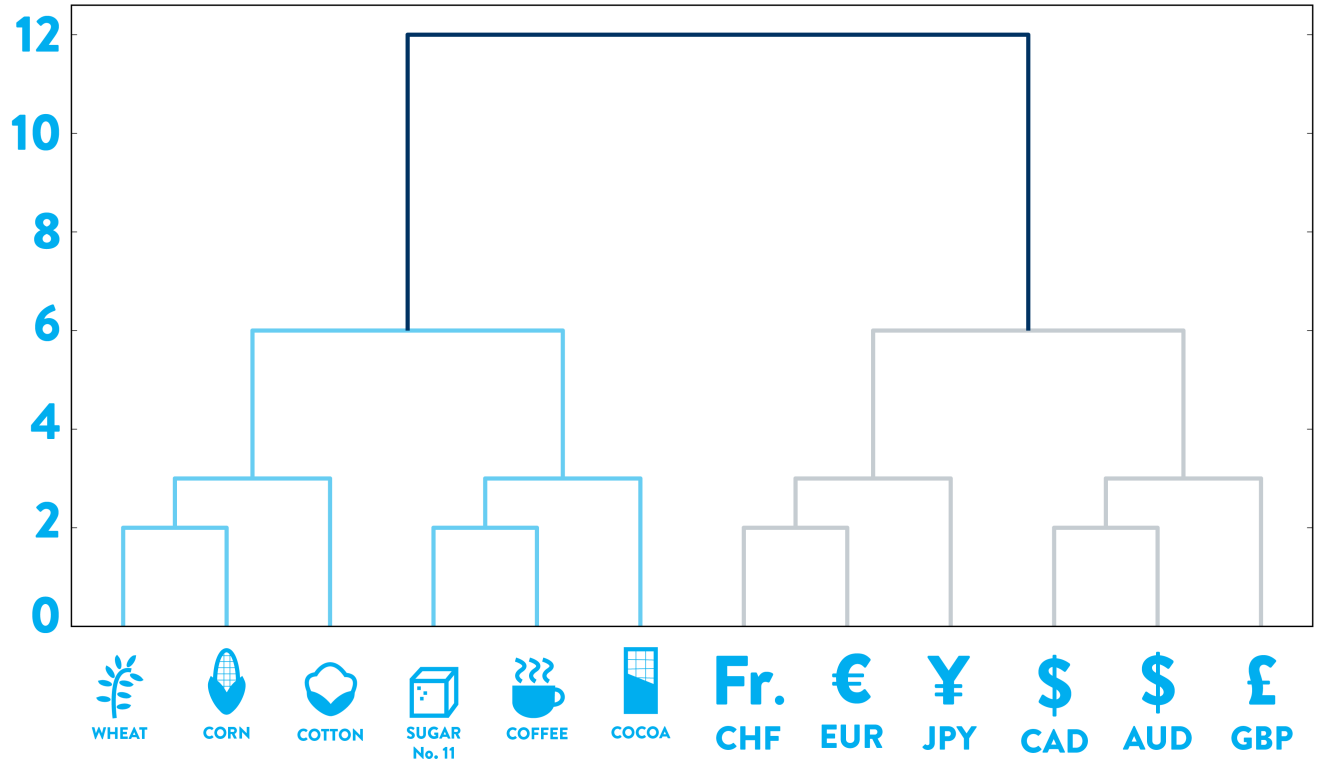
Quantum-inspired Hierarchical Risk Parity

How does QHRP work?



Split the list down the middle, then split the two resulting lists. Continue doing this until the resulting lists have only 1 asset to build a hierarchy. Importantly, each node in the hierarchy is a portfolio of two portfolios.

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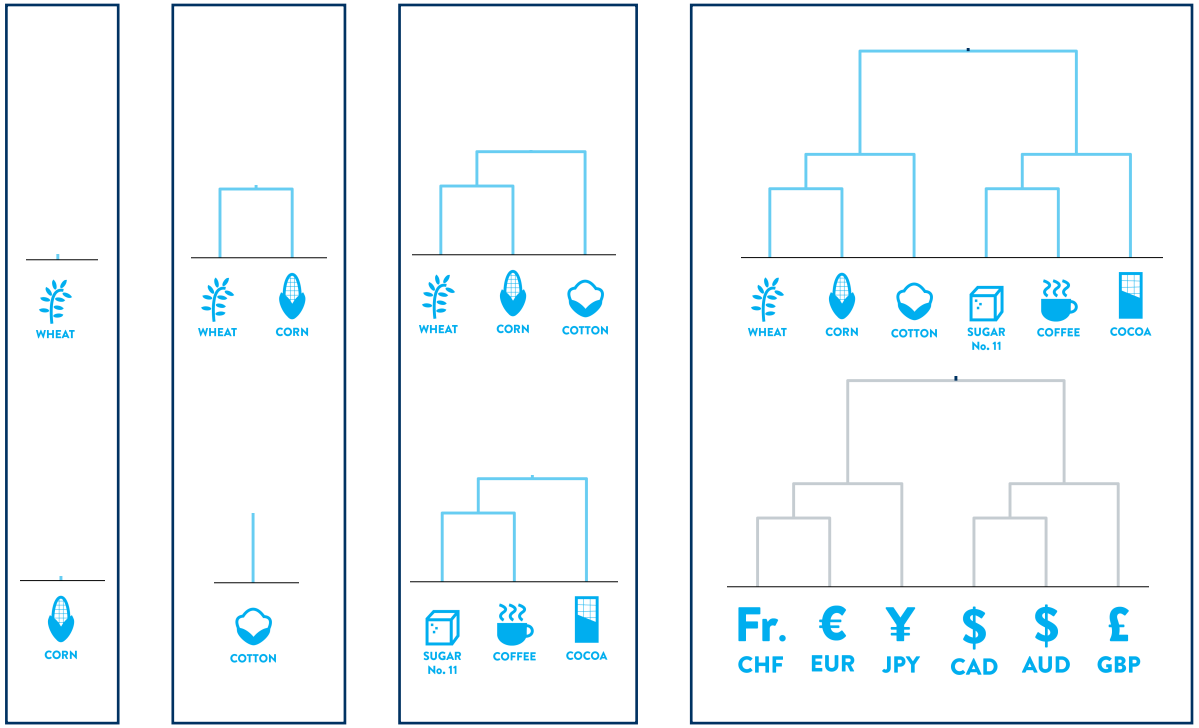
Quantum-inspired Hierarchical Risk Parity

How does QHRP work?



Run portfolio optimization at each node from the bottom to the top by blending together the two portfolios below it in the hierarchy. Specifically, calculate the risk of each of the two components at each node and weight each proportionally to the inverse of the risk. This equalizes the risk between the two at each stage, thus the *risk parity* in QHRP.

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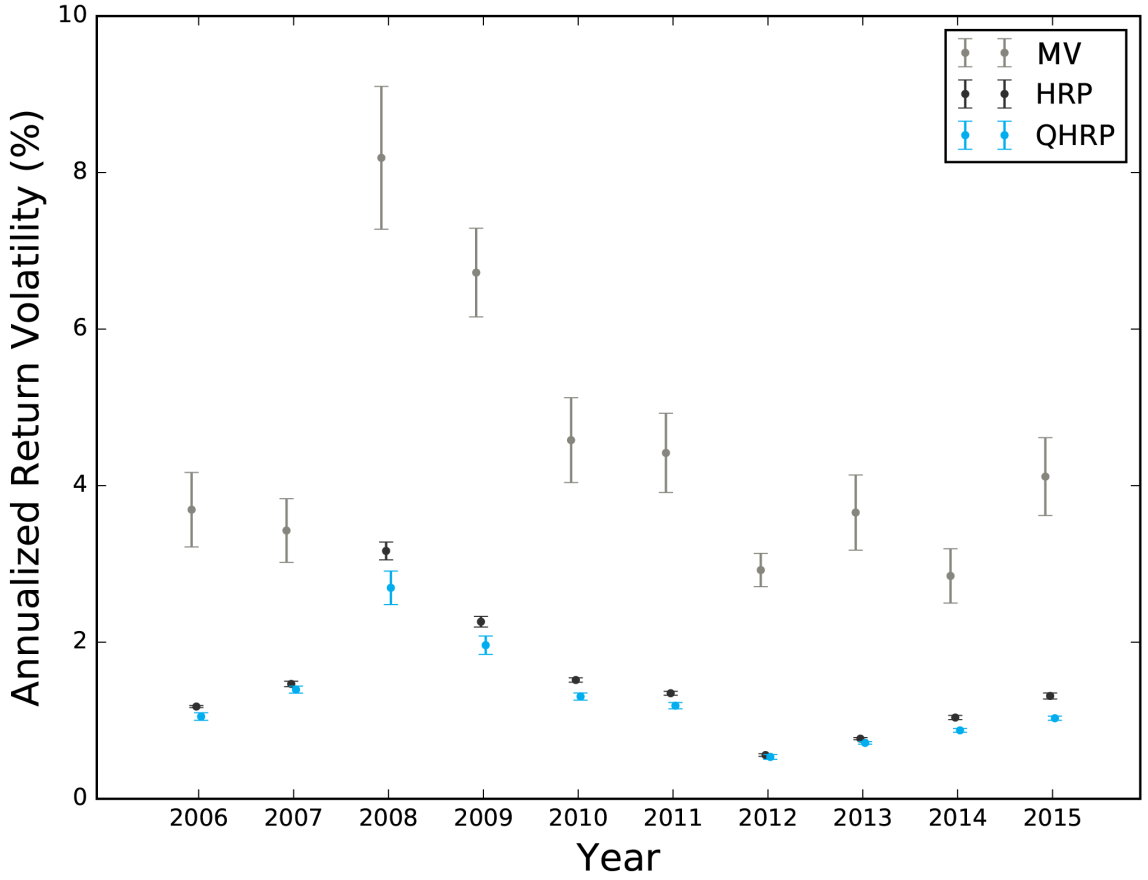
Quantum-inspired Hierarchical Risk Parity

Results



Method	Maximum Drawdown (%)
MV	14.9 ± 2.7
HRP	5.0 ± 0.6
QHRP	2.5 ± 0.9

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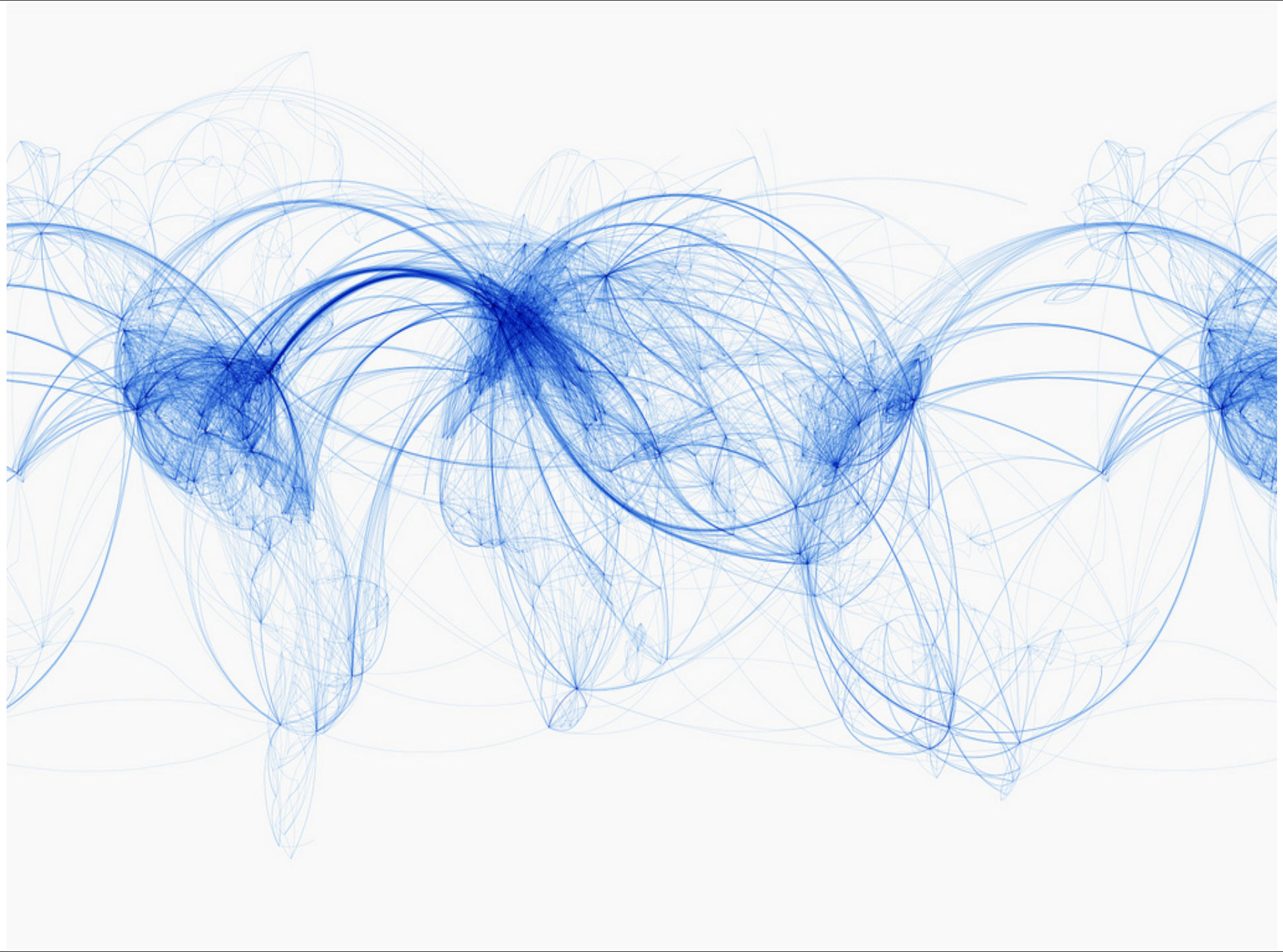
Big Data Visualization Tool (BiDViT)

Big Data Visualization Tool (BiDViT)

Summary of the research

Problem: Clustering is a well-used method in the field of unsupervised machine learning. The task becomes hard for large dataset and even harder when the number of clusters are large. Here we devise a quantum-inspired algorithm which clusters a dataset into multiple clusters.

Claim: We have devised a quantum-inspired clustering algorithm outperforming the state of the art algorithm in terms of the run-time (when the number of clusters are above some threshold).



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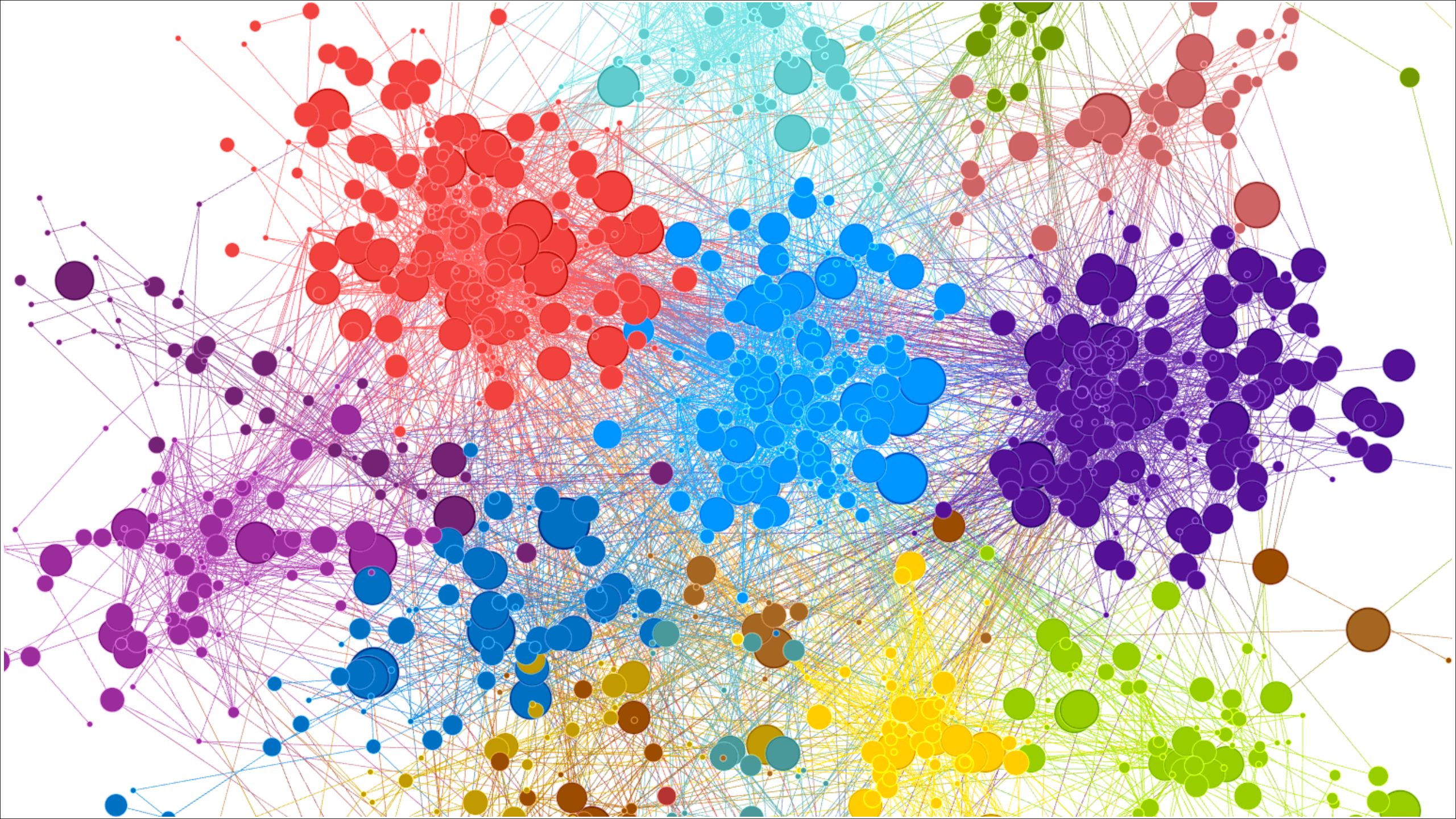
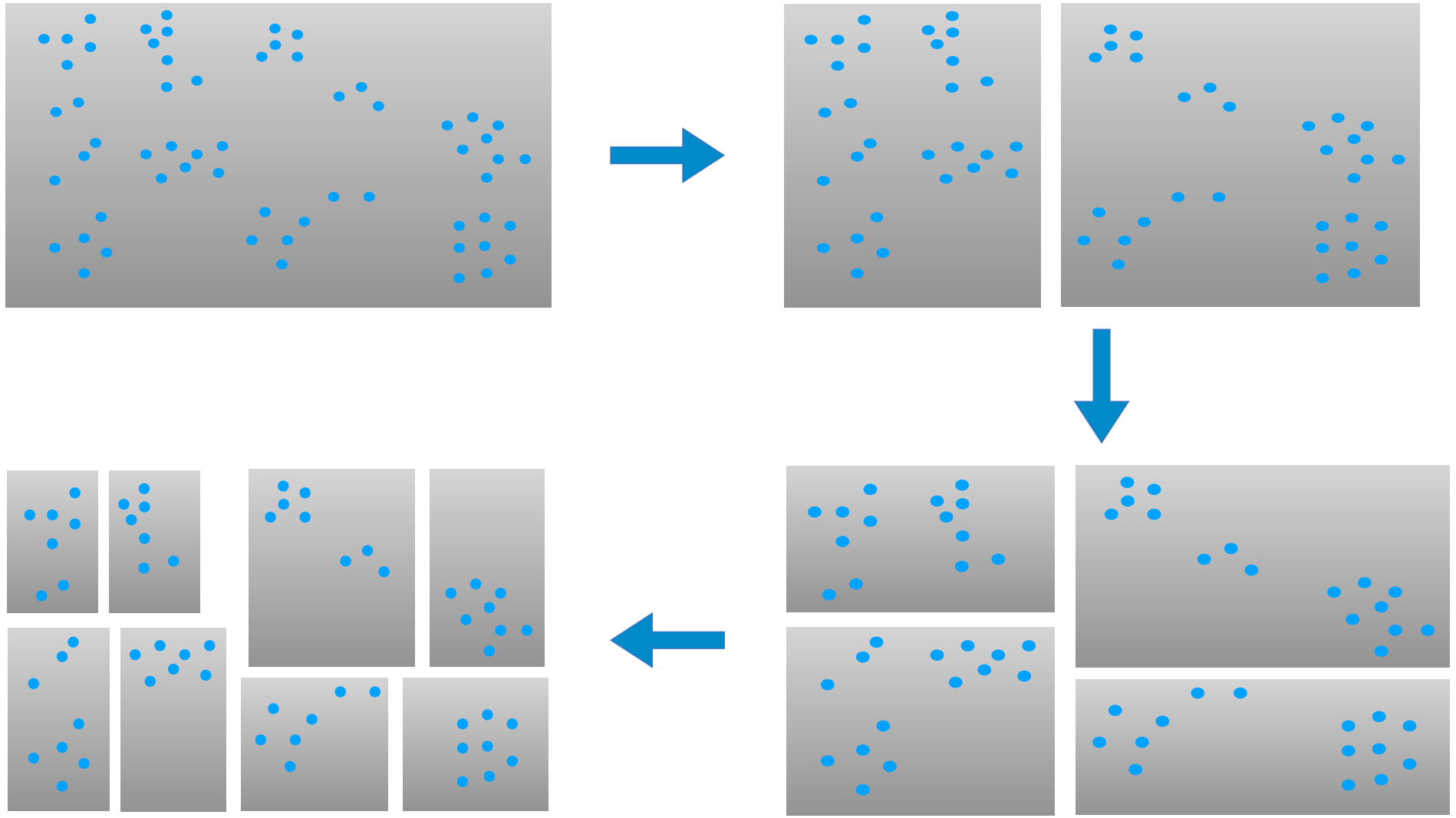


Big Data Visualization Tool

How does BiDViT work? — Chunking the dataset



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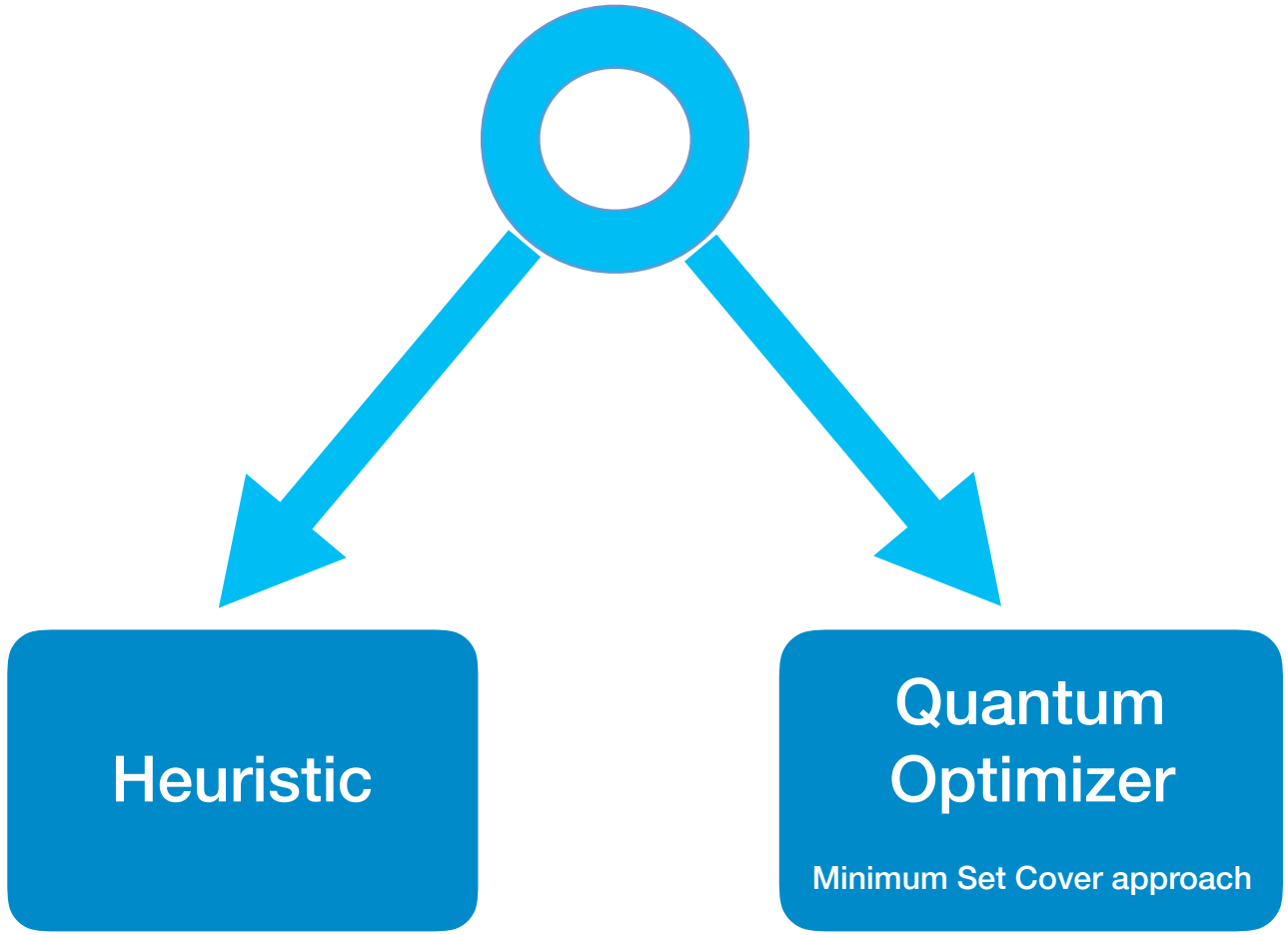
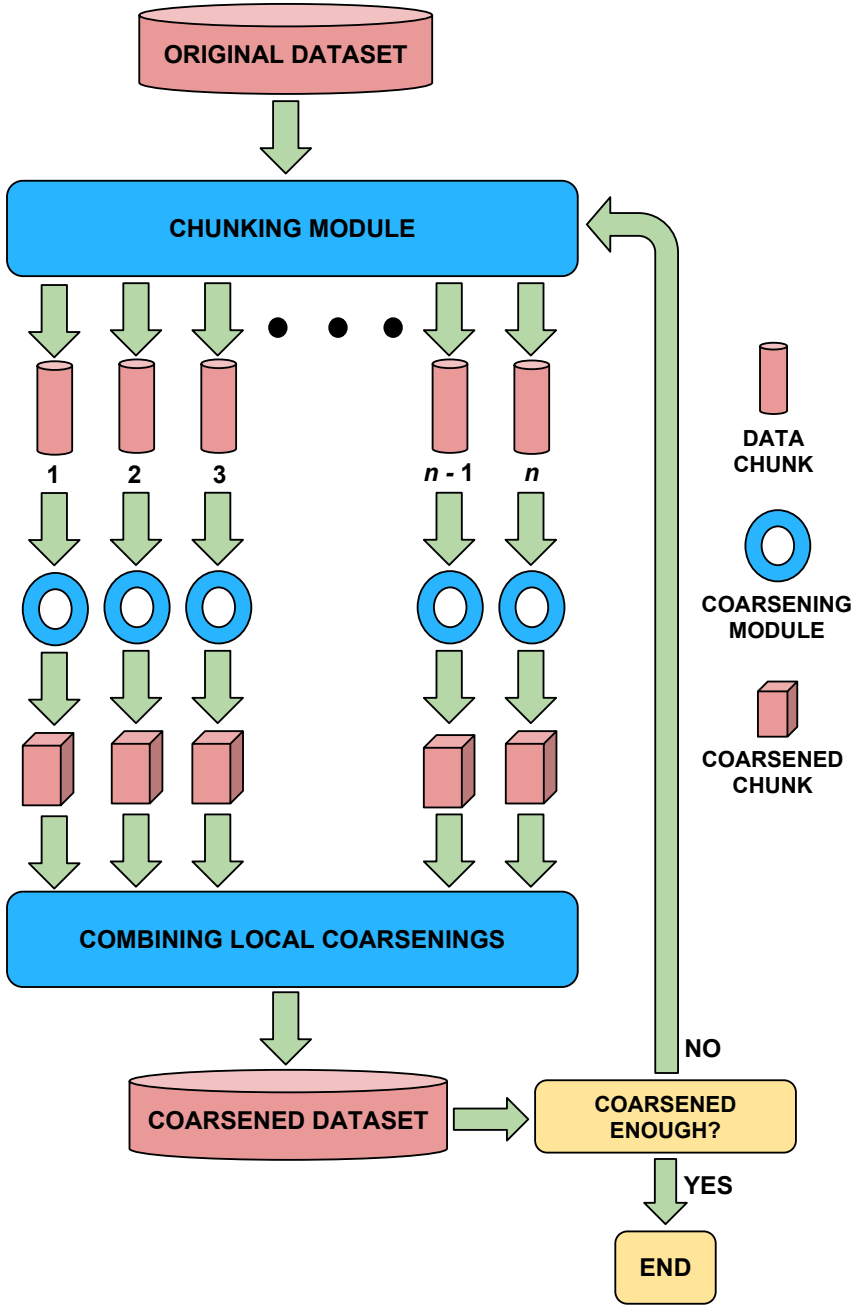
Big Data Visualization Tool

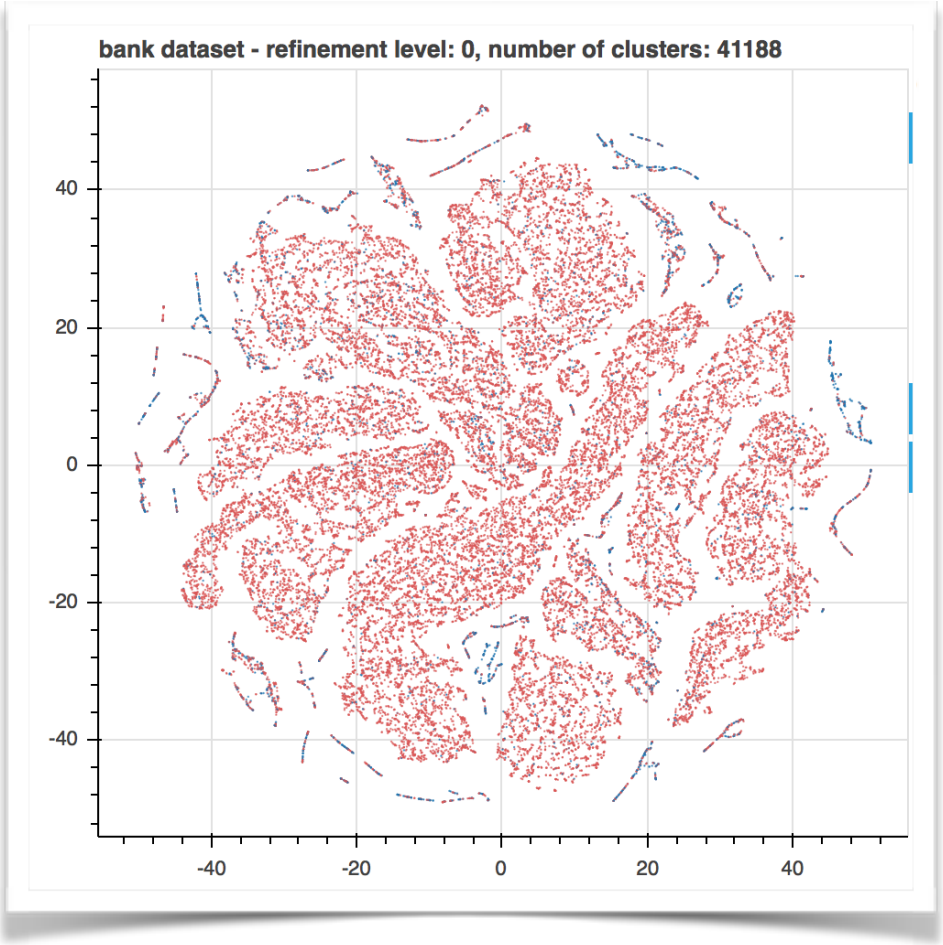
How does BiDViT work? — Pipeline

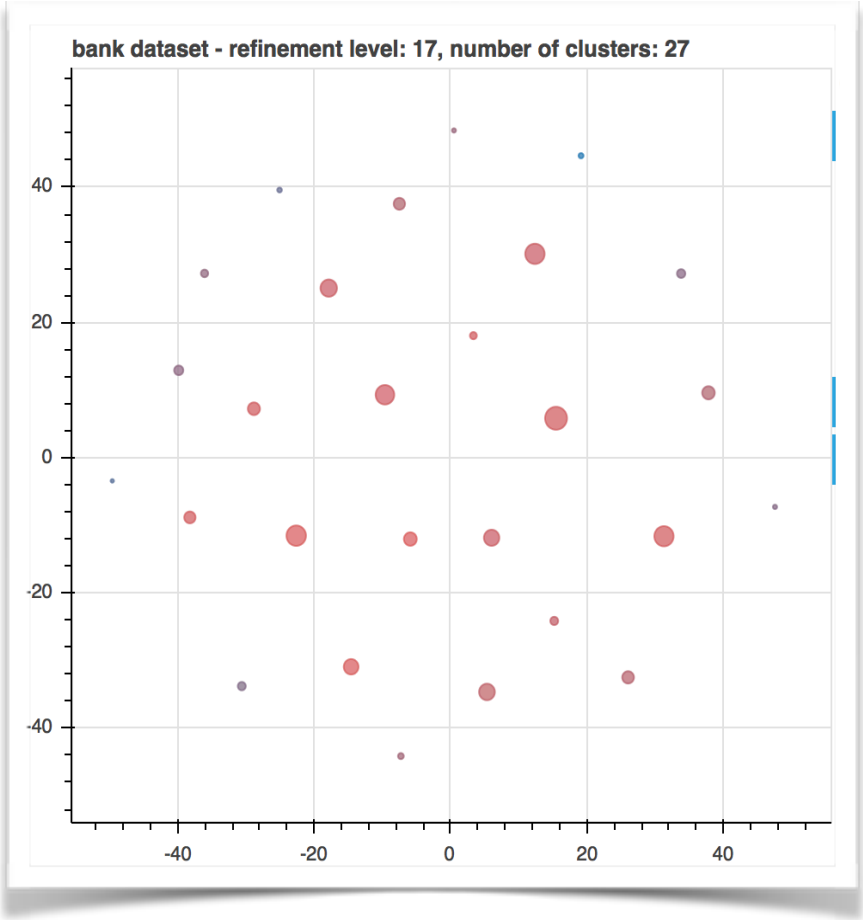




Big Data Visualization Tool

Results





Signed Graph Clustering

Signed Graph Clustering

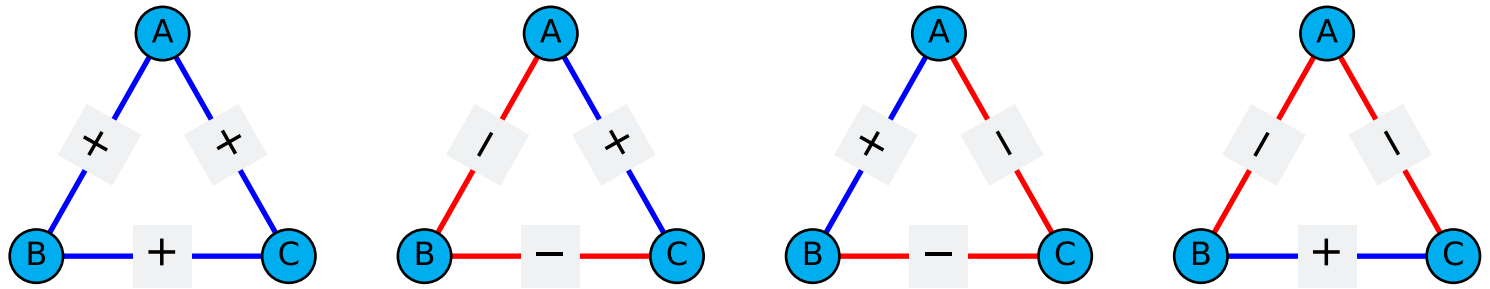
Summary of the research

Problem: Given a social network we developed an algorithm that takes the number of clusters as an upper-bound and find the optimal number of balanced cluster in the graph.

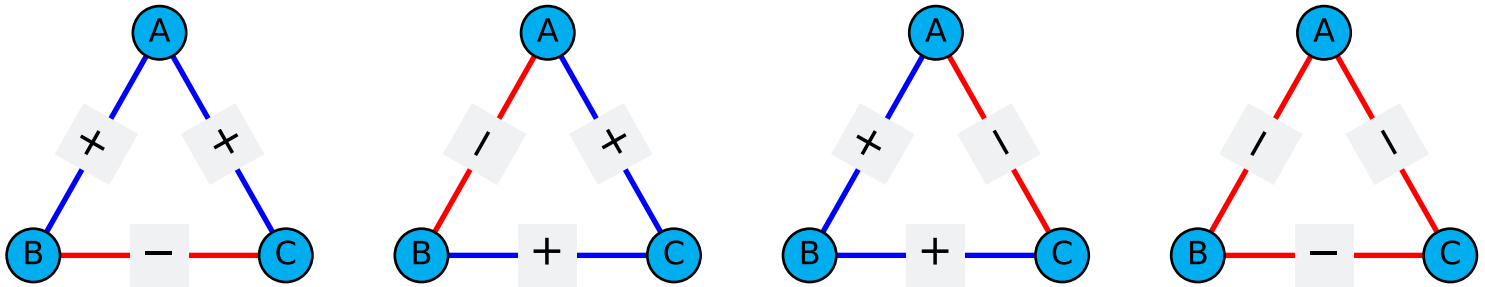
Claim: A quantum-inspired clustering algorithm which finds the optimal number of clusters within a social network given an upper-bound as the number of clusters by the user.

Signed Graph Clustering

Balance theory and sociological science



Stable configurations



Unstable configurations

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Signed Graph Clustering

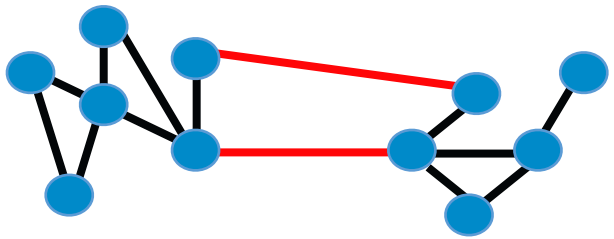
How does SGC work? — Pipeline

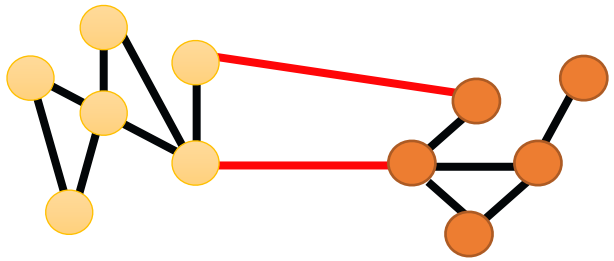
Encoding nodes using one-hot-encoding

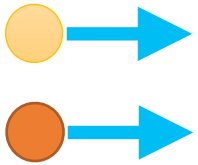
Optimize frustration or modularity measures

Optimize QUBO

one-hot-encoding







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[1,0,0,0,0]

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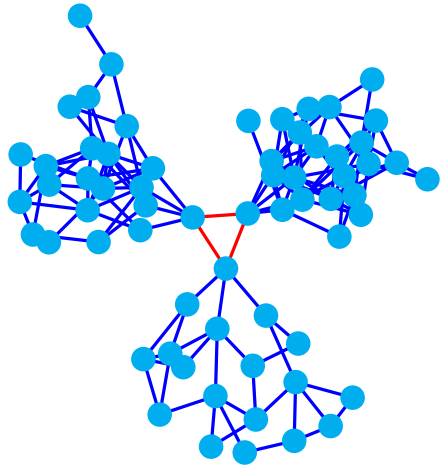
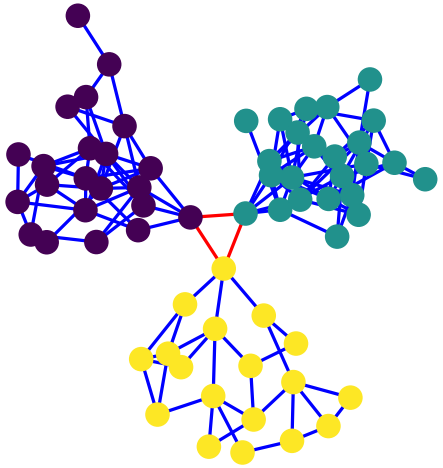
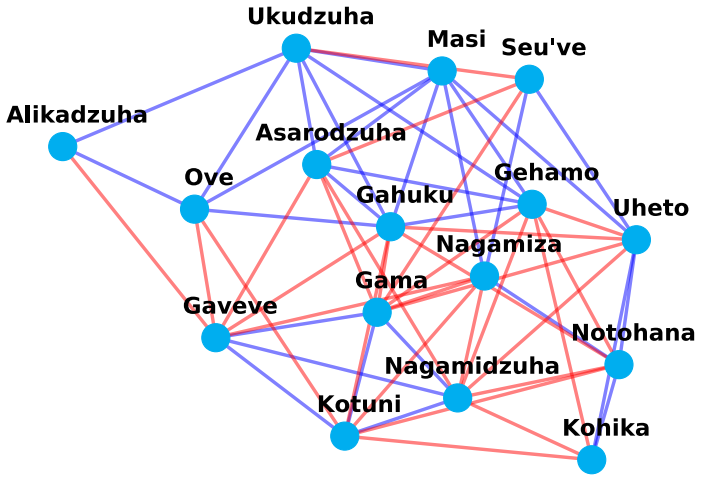
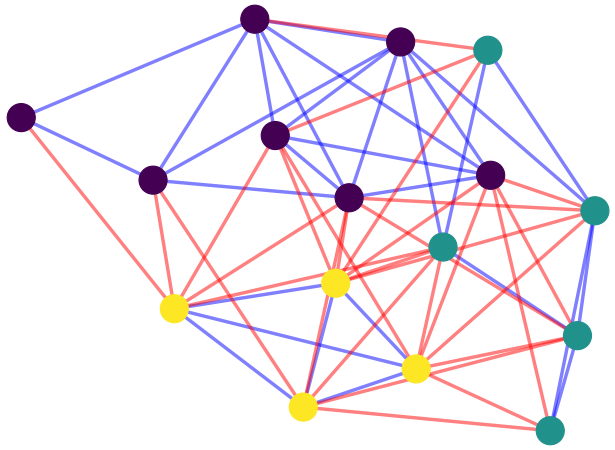
Signed Graph Clustering

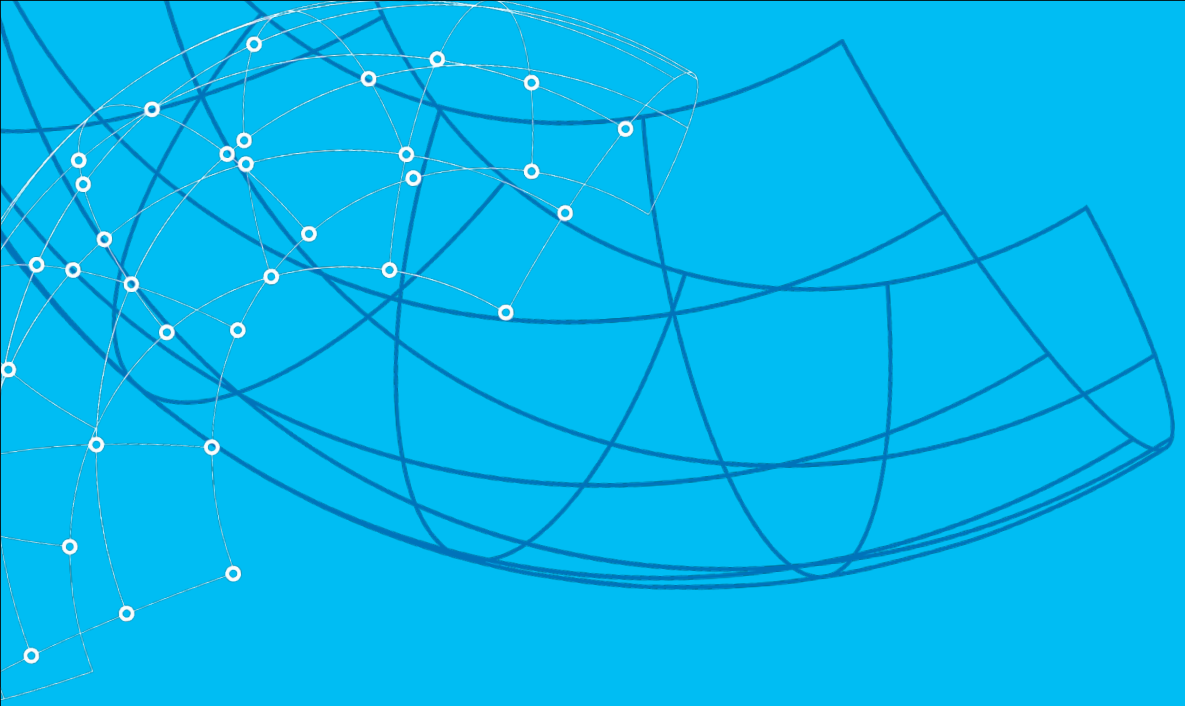
Results











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