Angle-based Joint and Individual Variation Explained (AJIVE)

NSF Big Data Grant 1633074 Statistical Approaches to Big Data Analytics
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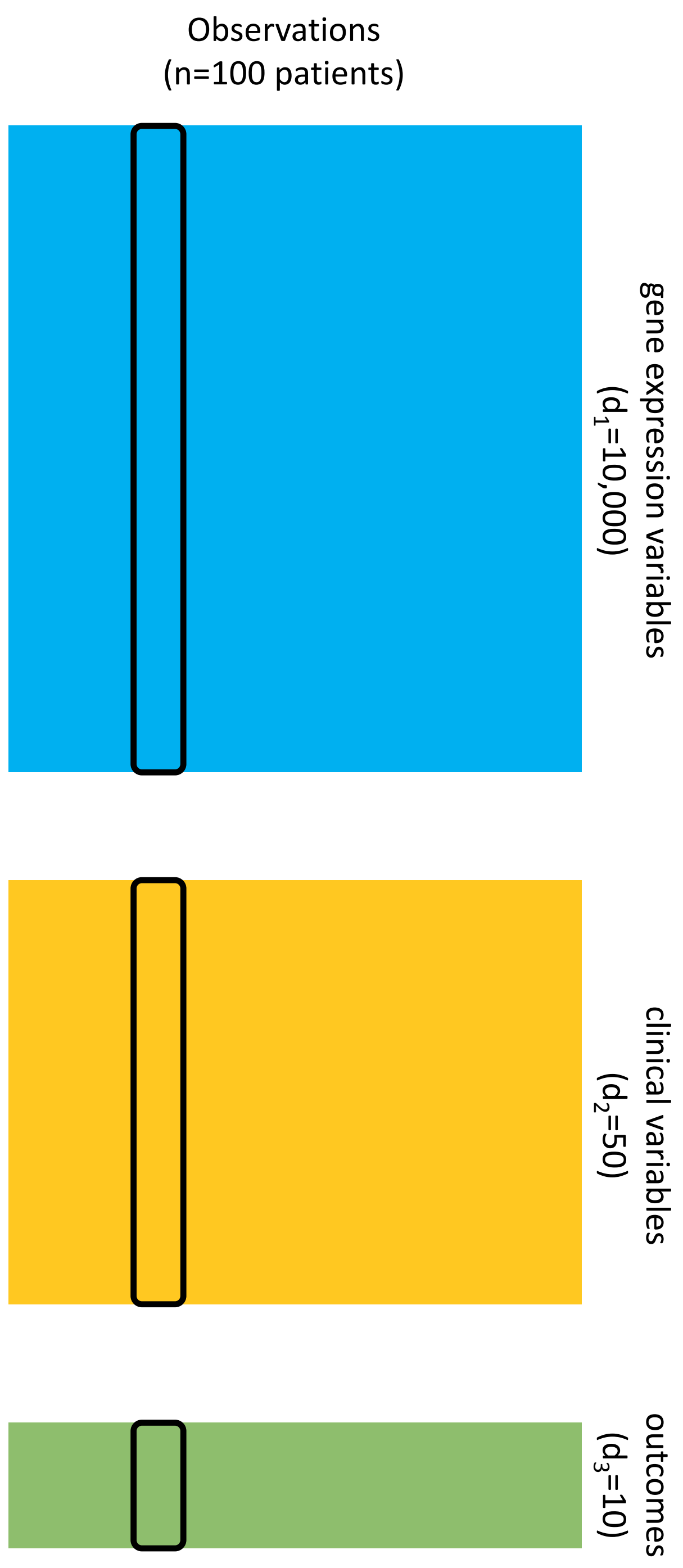
Project Description and Impacts

Data integration, **feature extraction** and **compare/contrast** capabilities for multiple, heterogeneous data blocks

Multi-block data: fixed set of observations, multiple sets of variables

- Gene expression, mutation, copy number, proteins, …
- Tumor H&E images and genetic data
- fMRI and behavioral scores
- Text and image data
- Citation network and text documents



Applications in

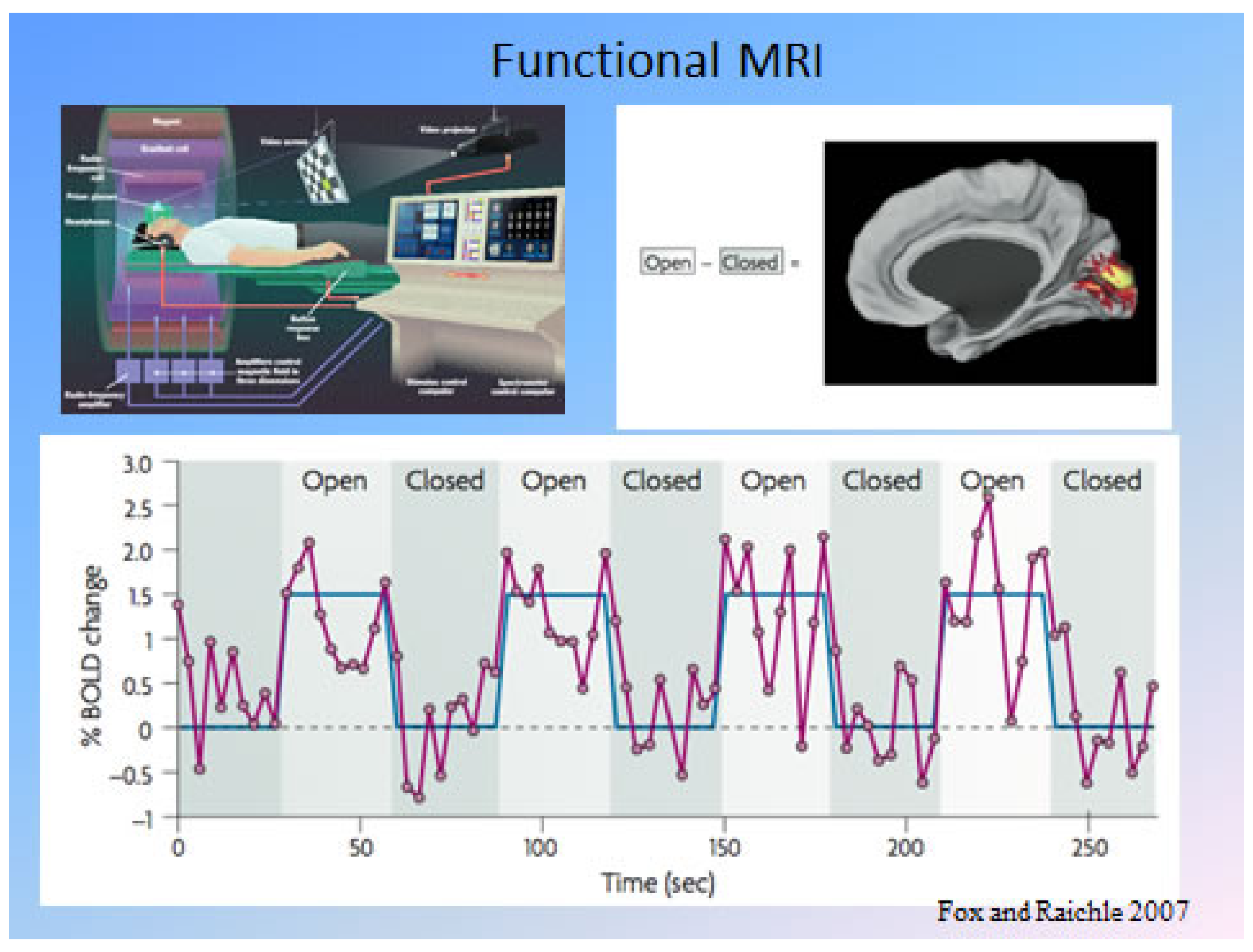
- Cancer genetics
- Neuroscience
- Natural language processing
- Medical image analysis
- Multi-modal machine learning

Unique challenges for multi-block setting

- Statistical inference
- Non-orthogonal decomposition
- Wildly different block scaling and dimensionality
- Heterogeneous signals (block individual, block joint, partially shared)
- Multiple, non-standard rank estimation problems
- Batch effects

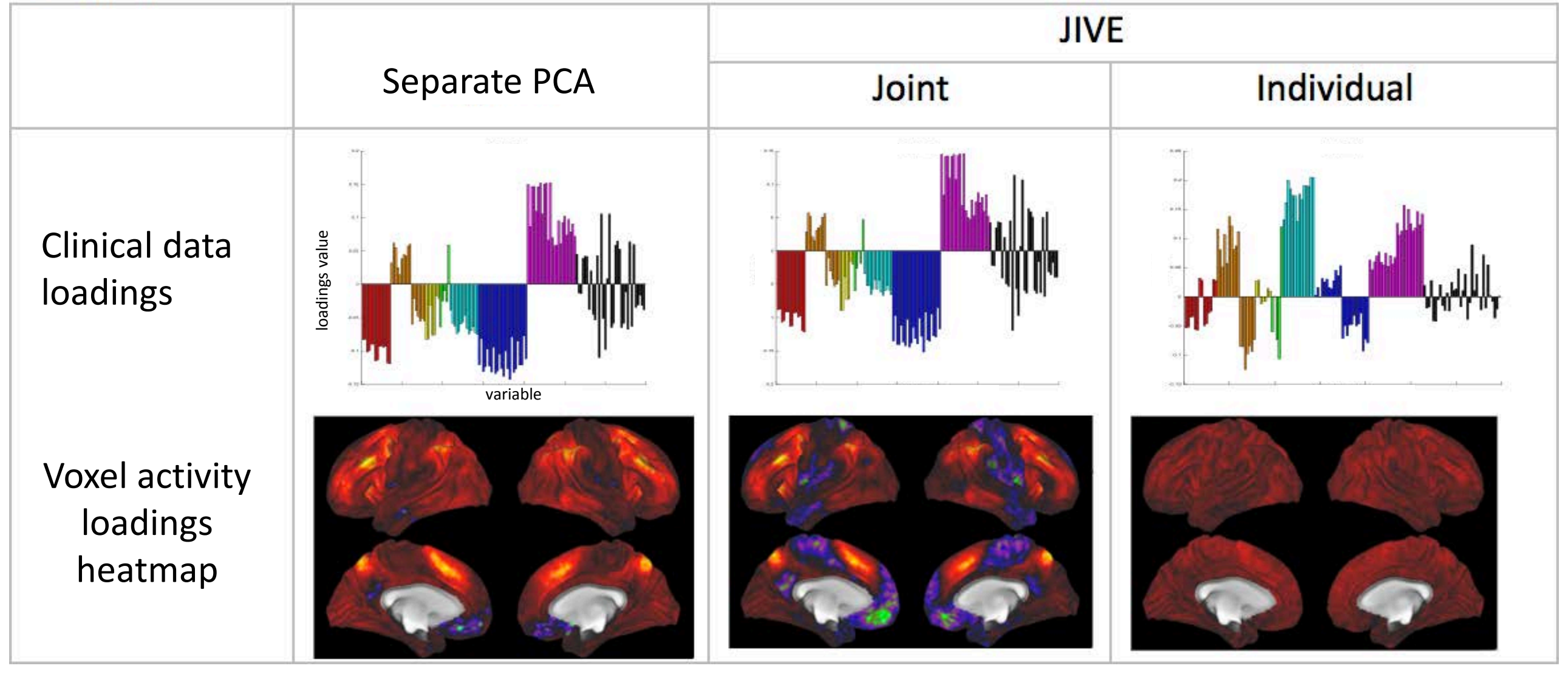
Functional MR Imaging

Disentangle important modes of variation



Fox and Raichle 2007

Visualize Using PC Loadings



Yu et al, 2017

Approach

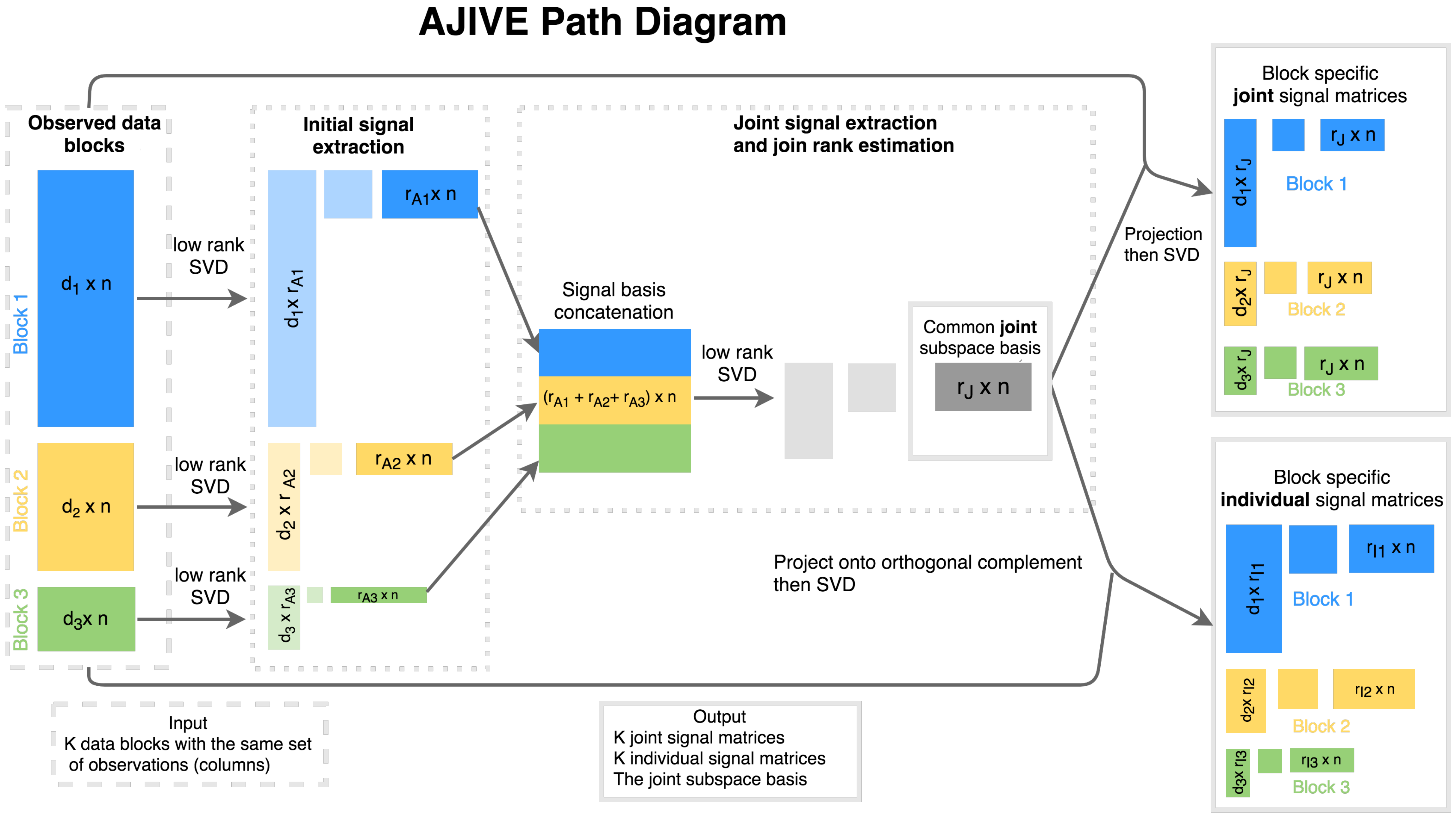
Statistical inference to identify **multiple kinds of shared signals**

- Shared by all blocks
- Partially shared (e.g. blocks 1, 3, 5)
- Individual (e.g. present in block 2 only)

Mathematical/statistical tools

- Principal angle analysis
- Singular Value Decomposition
- Second order cone programming
- Perturbation analysis
- Bootstrap

AJIVE Path Diagram



Progress and Future Directions

Partially shared block analysis via **new perturbation framework**

- New direction-based approach
- Bootstrap based improvement to Wedin bound
- Major improvement for non-square matrices

Improved **methodology and computation**

- Manifold optimization
- Difference of convex functions (DC) programming

Future applications

- Supervised JIVE for cancer genetics
    - Incorporate subtype information
    - Clinical outcomes/survival
- Deep learning integration with JIVE
    - Medical image analysis and genetic applications
    - Search for genetic drivers
    - Interpretation of extracted features
    - True integration
- Bayesian JIVE (Zhao et al, 2016)
    - Novel priors
    - Non-orthogonal partially shared blocks
    - Subspace based sampling
- Continuous time data blocks
    - Language evolution with word embeddings
    - High-frequency financial data

References

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