# Data-driven Power Flow Linearization: Theory
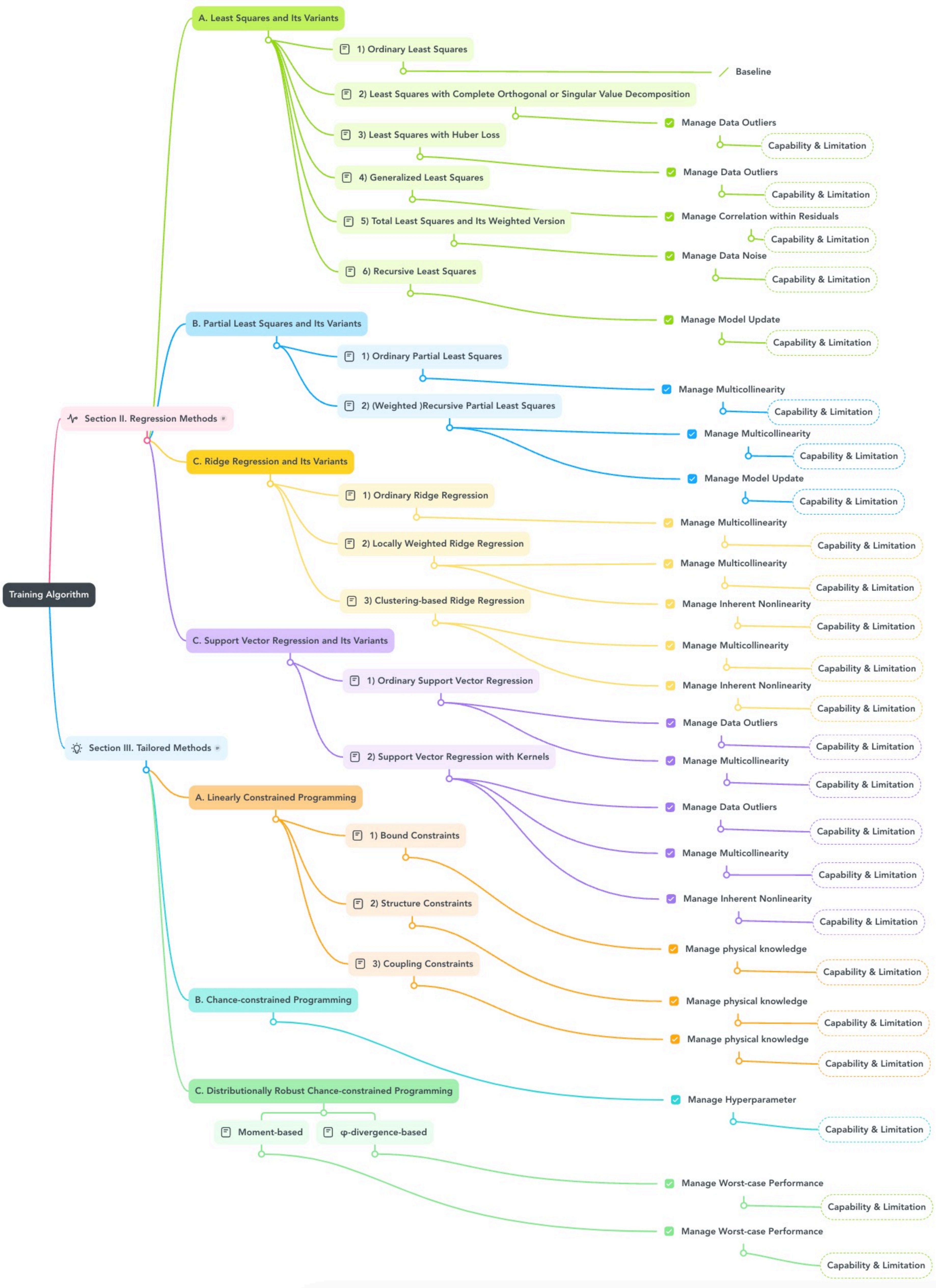## Supplementary Material

Mengshuo Jia, *Member, IEEE,* Gabriela Hug, *Senior Member, IEEE*, Ning Zhang, *Senior Member, IEEE*, Zhaojian Wang, *Member, IEEE*, Yi Wang, *Member, IEEE*, and Chongqing Kang, *Fellow, IEEE,*

# Training Algorithm

## Section II. Regression Methods

### A. Least Squares and Its Variants
- 1) Ordinary Least Squares
  - Baseline
- 2) Least Squares with Complete Orthogonal or Singular Value Decomposition
  - ✅ Manage Data Outliers
    - Capability & Limitation
- 3) Least Squares with Huber Loss
  - ✅ Manage Data Outliers
    - Capability & Limitation
- 4) Generalized Least Squares
  - ✅ Manage Correlation within Residuals
    - Capability & Limitation
- 5) Total Least Squares and Its Weighted Version
  - ✅ Manage Data Noise
    - Capability & Limitation
- 6) Recursive Least Squares
  - ✅ Manage Model Update
    - Capability & Limitation

### B. Partial Least Squares and Its Variants
- 1) Ordinary Partial Least Squares
  - ✅ Manage Multicollinearity
    - Capability & Limitation
- 2) (Weighted )Recursive Partial Least Squares
  - ✅ Manage Multicollinearity
    - Capability & Limitation
  - ✅ Manage Model Update
    - Capability & Limitation

### C. Ridge Regression and Its Variants
- 1) Ordinary Ridge Regression
  - ✅ Manage Multicollinearity
    - Capability & Limitation
- 2) Locally Weighted Ridge Regression
  - ✅ Manage Multicollinearity
    - Capability & Limitation
  - ✅ Manage Inherent Nonlinearity
    - Capability & Limitation
- 3) Clustering-based Ridge Regression
  - ✅ Manage Multicollinearity
    - Capability & Limitation
  - ✅ Manage Inherent Nonlinearity
    - Capability & Limitation

### C. Support Vector Regression and Its Variants
- 1) Ordinary Support Vector Regression
  - ✅ Manage Data Outliers
    - Capability & Limitation
  - ✅ Manage Multicollinearity
    - Capability & Limitation
- 2) Support Vector Regression with Kernels
  - ✅ Manage Data Outliers
    - Capability & Limitation
  - ✅ Manage Multicollinearity
    - Capability & Limitation
  - ✅ Manage Inherent Nonlinearity
    - Capability & Limitation

## Section III. Tailored Methods

### A. Linearly Constrained Programming
- 1) Bound Constraints
  - ✅ Manage physical knowledge
    - Capability & Limitation
- 2) Structure Constraints
  - ✅ Manage physical knowledge
    - Capability & Limitation
- 3) Coupling Constraints
  - ✅ Manage physical knowledge
    - Capability & Limitation

### B. Chance-constrained Programming
- ✅ Manage Hyperparameter
  - Capability & Limitation

### C. Distributionally Robust Chance-constrained Programming
- Moment-based
  - ✅ Manage Worst-case Performance
    - Capability & Limitation
- φ-divergence-based
  - ✅ Manage Worst-case Performance
    - Capability & Limitation

# Section IV. Supportive Technique

## A. Variable Bundle Strategy
→ Manage Bus-type Variation
- Capability
- Limitation
- Generalizability

## B. Variable Coordinate Transformation
→ Manage Nonlinearity of AC Power Flow
- 1) Voltage Squaring
- 2) Voltage-angle Coupling
- 3) Dimension Lifting
- Capability
- Limitation
- Generalizability

## C. Physical Model Integration
→ Manage the Integration of Physical Knowledge
- 1) Coefficient Optimization
- 2) Error Correction
- Capability
- Limitation
- Generalizability