StochasticPowerModels

The StochasticPowerModels core developers and contributors

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Contents

Part I

Home

Chapter 1

StochasticPowerModels.jl Documentation

1.1 Overview

StochasticPowerModels.jl is a research-grade Julia/JuMP package for experimentation with Steady-State Power Network Optimization under uncertainty, extending PowerModels.jl.

1.2 Installation

For now, StochasticPowerModels is unregistered. Nevertheless, you can install it through

```
] add https://github.com/timmyfaraday/StochasticPowerModels.jl.git
```

At least one solver is required for running StochasticPowerModels. The open-source solver Ipopt is recommended, as it is fast, scaleable and can be used to solve a wide variety of the problems and network formulations provided in PowerModels. The Ipopt solver can be installed via the package manager with

```
] add Ipopt
```

Test that the package works by running

```
] test StochasticPowerModels
```

Part II

Manual

Chapter 2

Getting Started

2.1 Quick Start Guide

Once StochasticPowerModels is installed, Ipopt is installed, and a network data file (e.g. `"case5_spm.m"`) has been acquired, an stochatic AC Optimal Power Flow can be executed with,

```julia
using StochasticPowerModels
using Ipopt

result = run_ac_sopf("matpower/case5_spm.m", Ipopt.Optimizer)
```

Chapter 3

Mathematical Model

3.1 The StochasticPowerModels Mathematical Model

Sets and Parameters

StochasticPowerModels implements a generalized polynomial chaos expansion version of the AC Optimal Power Flow problem from Matpower. The core generalizations of the deterministic OPF problem are,

- Support for multiple load (S_k^d) and shunt (Y_k^s) components on each bus i

- Line charging that supports a conductance and asymmetrical values (Y_{ij}^c, Y_{ji}^c)

sets:

N - buses

R - reference buses

E, E^R - branches, forward and reverse orientation

G, G_i - generators and generators at bus i

L, L_i - loads and loads at bus i

S, S_i - shunts and shunts at bus i

data:

$S_k^{gl}, S_k^{gu} \quad \forall k \in G$ - generator complex power bounds

$c_{2k}, c_{1k}, c_{0k} \quad \forall k \in G$ - generator cost components

$v_i^l, v_i^u \quad \forall i \in N$ - voltage bounds

$S_k^d \quad \forall k \in L$ - load complex power consumption

$Y_k^s \quad \forall k \in S$ - bus shunt admittance

$Y_{ij}, Y_{ij}^c, Y_{ji}^c \quad \forall (i, j) \in E$ - branch pi-section parameters

$T_{ij} \quad \forall (i, j) \in E$ - branch complex transformation ratio

$s_{ij}^u \quad \forall (i, j) \in E$ - branch apparent power limit

$i_{ij}^u \quad \forall (i, j) \in E$ - branch current limit

$\theta_{ij}^{\Delta l}, \theta_{ij}^{\Delta u} \quad \forall (i, j) \in E$ - branch voltage angle difference bounds

(3.1)

Stochastic Optimal Power Flow in Current-Voltage Variables

A variable I_{ij}^s, representing the current in the direction i to j, through the series part of the pi-section, is used. The mathematical structure for a current-voltage formulation is conceived as:

variables:

$$I_k^g \ \ \forall k \in G$$

$$V_i \ \ \forall i \in N$$

$$I_{ij}^s \ \ \forall(i,j) \in E \cup E^R \text{ - branch complex (series) current} \tag{3.2}$$

$$I_{ij} \ \ \forall(i,j) \in E \cup E^R \text{ - branch complex (total) current} \tag{3.3}$$

minimize: $\displaystyle\sum_{k \in G} c_{2k}(\Re(S_k^g))^2 + c_{1k}\Re(S_k^g) + c_{0k}$

subject to:

$$\angle V_r = 0 \ \ \forall r \in R$$

$$S_k^{gl} \le \Re(V_i(I_k^g)^*) + j\Im(V_i(I_k^g)^*) \le S_k^{gu} \ \ \forall k \in G \tag{3.4}$$

$$v_i^l \le |V_i| \le v_i^u \ \ \forall i \in N$$

$$\sum_{k \in G_i} I_k^g - \sum_{k \in L_i} (S_k^d/V_i)^* - \sum_{k \in S_i} Y_k^s V_i = \sum_{(i,j) \in E_i \cup E_i^R} I_{ij} \ \ \forall i \in N \tag{3.5}$$

$$I_{ij} = \frac{I_{ij}^s}{T_{ij}^*} + Y_{ij}^c \frac{V_i}{|T_{ij}|^2} \ \ \forall(i,j) \in E \tag{3.6}$$

$$I_{ji} = -I_{ij}^s + Y_{ji}^c V_j \ \ \forall(i,j) \in E \tag{3.7}$$

$$\frac{V_i}{T_{ij}} = V_j + z_{ij} I_{ij}^s \ \ \forall(i,j) \in E \tag{3.8}$$

$$|S_{ij}| = |V_i||I_{ij}| \le s_{ij}^u \ \ \forall(i,j) \in E \cup E^R$$

$$|I_{ij}| \le i_{ij}^u \ \ \forall(i,j) \in E \cup E^R$$

$$\theta_{ij}^{\Delta l} \le \angle(V_i V_j^*) \le \theta_{ij}^{\Delta u} \ \ \forall(i,j) \in E$$

Stochastic Optimal Power Flow in Power-Voltage Variables

A complete mathematical model is as follows,

variables:

$$S_k^g \quad \forall k \in G \text{ - generator complex power dispatch} \tag{3.9}$$

$$V_i \quad \forall i \in N \text{ - bus complex voltage} \tag{3.10}$$

$$S_{ij} \quad \forall (i,j) \in E \cup E^R \text{ - branch complex power flow} \tag{3.11}$$

minimize: $$\sum_{k \in G} c_{2k}(\Re(S_k^g))^2 + c_{1k}\Re(S_k^g) + c_{0k} \tag{3.12}$$

subject to:

$$\angle V_r = 0 \quad \forall r \in R \tag{3.13}$$

$$S_k^{gl} \leq S_k^g \leq S_k^{gu} \quad \forall k \in G \tag{3.14}$$

$$v_i^l \leq |V_i| \leq v_i^u \quad \forall i \in N \tag{3.15}$$

$$\sum_{k \in G_i} S_k^g - \sum_{k \in L_i} S_k^d - \sum_{k \in S_i} (Y_k^s)^* |V_i|^2 = \sum_{(i,j) \in E_i \cup E_i^R} S_{ij} \quad \forall i \in N \tag{3.16}$$

$$S_{ij} = \left(Y_{ij} + Y_{ij}^c\right)^* \frac{|V_i|^2}{|T_{ij}|^2} - Y_{ij}^* \frac{V_i V_j^*}{T_{ij}} \quad \forall (i,j) \in E \tag{3.17}$$

$$S_{ji} = \left(Y_{ij} + Y_{ji}^c\right)^* |V_j|^2 - Y_{ij}^* \frac{V_i^* V_j}{T_{ij}^*} \quad \forall (i,j) \in E \tag{3.18}$$

$$|S_{ij}| \leq s_{ij}^u \quad \forall (i,j) \in E \cup E^R \tag{3.19}$$

$$|I_{ij}| \leq i_{ij}^u \quad \forall (i,j) \in E \cup E^R \tag{3.20}$$

$$\theta_{ij}^{\Delta l} \leq \angle(V_i V_j^*) \leq \theta_{ij}^{\Delta u} \quad \forall (i,j) \in E \tag{3.21}$$

Part III

Library

Chapter 4

Network Formulations

4.1 Network Formulations

Type Hierarchy

We begin with the top of the hierarchy, where we can distinguish between current-voltage and power-voltage formulations

```
AbstractACPModel <: AbstractPowerModel
AbstractIVRModel <: AbstractPowerModel
```

Power Models

Each of these forms can be used as the model parameter for a PowerModel:

```
ACPPowerModel <: AbstractACPForm
IVRPowerModel <: AbstractIVRModel
```