



Forme des solutions synchrones dans des modèles de réseau de transport électrique

Spécialité Physique statistique

Niveau d'étude Bac+5

Formation Master 2

Unité d'accueil

Candidature avant le 13/01/2017

Durée 5 mois

Poursuite possible en thèse oui

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Résumé

Dans le modèle de Kuramoto généralisé, des producteurs et des consommateurs de courant alternatif sont représentés par des oscillateurs dans un réseau couplé. Pour comprendre la stabilité du réseau, nous étudierons les solutions stationnaires en fonction de la topologie.

Sujet détaillé

Le stagiaire travaillera dans le cadre du projet NESTOR (avec Stefan Wieland), qui vise à déterminer les façons les plus stables d'inclure des technologies de stockage de l'énergie dans les réseaux électriques.
cf. texte en anglais pour la description.

Mots clés

Systèmes complexes, réseaux électriques, oscillateurs couplés, modèle de Kuramoto, simulations numériques, synchronisation,

Compétences

Logiciels

C, Python, Matlab ou Mathematica

The form of synchronized solutions in power-grid models

Summary

In the generalized Kuramoto model, producers and consumers of alternative current are represented by coupled oscillators constituting a power grid. In order to investigate grid stability, we will study the form of steady state solutions as a function of grid topology.

Full description

The intern will work within project NESTOR, with Stefan Wieland. NESTOR aims at the determination of best strategies to include energy storage technologies in power grids.

Many real-world systems can be considered networks of coupled phase oscillators, with power transmission grids often being described by an extension of the paradigmatic Kuramoto model. In this setting, an oscillator's phase is driven both by its own natural frequency and by its phase difference to connected oscillators. Oscillators with positive and negative natural frequencies can be associated with power grid producers and consumers, respectively (Filatrella et al. 2008). For stable grid operations, frequency synchronization of all oscillators is necessary, which is achieved for sufficiently strong coupling. In an appropriately chosen co-rotating reference frame, this synchronization translates into a steady state where all oscillator phases are "locked". The shape of these phase-locked solutions generally depends on the underlying grid topology, and moreover hints at constraints on the system's flow even outside the steady state. Hence knowing and predicting the shape of phase-locked solutions has a twofold importance: In modelling, a massive complexity reduction can be achieved by just considering dynamics in aforementioned constrained subspaces (Gottwald et al. 2015), so that an analytically tractable description of the high-dimensional original system becomes feasible. In practice, phase-locked configurations are of interest to power engineers, as they expose transmission lines along which the power flow may exceed critical limits.

The proposed internship aims to describe and perhaps to explain the form of phase-locked solutions for several grid topologies. To that end, the prospective intern would

- write and run simulations of Kuramoto-type dynamics on various simple network topologies.
- search for closed-form expressions of resulting phase-locked solutions through fitting routines and/or heuristic arguments.
- using said expressions to set up simplified models (time permitting).

Programming skills in either C, Python, Matlab or Mathematica are required, as well as an interest in nonlinear dynamics and the theory of complex networks.

references:

https://en.wikipedia.org/wiki/Kuramoto_model

G. Filatrella, H. A. Nielsen, and F. N. Pedersen. Analysis of a power grid using a kuramoto-like model. The European Physical Journal B , 61(4), 2008

G. A. Gottwald. Model reduction for networks of coupled oscillators. Chaos , 25(5), 2015.

Keywords

Complex networks, power grids, coupled oscillators, Kuramoto model, numerical simulations, synchronization

Skills

Softwares

C, Python, Matlab ou Mathematica