2022 Future Computing Summer Internship Project: Detecting if simulated oscillators are following the Kuramoto Model by determining if the oscillators experience synchronization.

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Abstract

W.I.P.

1 Project Description

The challenge addressed by this work is to determine a correct and efficient way to analyze multiple oscillators and determine which oscillators are synchronized and which are not. The purpose for this is to detect synchronization of oscillators in simulation. This problem is being looked at due to the Kuramoto Model, which is a mathematical model that describes how coupled oscillators may synchronize over time. If this behavior is unintended and system architects are unaware of it, this can become a problem. In this case, an effort is put forward to detecting which oscillators are synchronized in a set and which are not.

2 Motivation

3 Prior work

Will properly explain these works later:

- Method of detecting synchronization by measuring peak synchronization in multiple signals [2]
- Method of detecting synchronization by defining events (such as peaks in signals) and does not require the calculation of phase [3]
- Comparison of multiple current methods for phase synchronization [1]

4 Running the Model

5 Result

Two primary methods at the moment:

Goal: Determine if the oscillators have the same frequency and are in phase. Assumption: The simulation keeps track of the oscillators frequency.

First method:

During a simulation, you can sample one period of data for a set of oscillators. The sampling will begin at the first peak that the simulation encounters, this will be the reference oscillator and its phase will be zero. As time steps forward, the time in which the first peak occurs for every oscillator in the period of time will be recorded.

Once the period is over, the collected data is analyzed. The phase difference is calculated for each oscillator by subtracting the time in which its first peak occurred by the reference oscillator's peak. This value is multiped by two pi to give the phase angle.

With the array/vector of phase angles between every oscillator and the reference, you can compare the phase angles of all the oscillators in quadratic time (n squared). Oscillators are synchronized if the phase angle is zero (in-phase) or pi (anti-phase).

Second Method:

Combine the oscillators and see if the amplitude is equal to the summation of all of the oscillators' amplitudes. This method may required converting analog signals to digital first. This can only detect global synchronization between the oscillators.

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6 Future Work

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References

[1]

[2] Rahul Biswas, Koulik Khamaru, and Kaushik K. Majumdar. A peak synchronization measure for multiple signals. *IEEE Transactions on Signal Processing*, 62(17):4390–4398, 2014.

[3] R. Quian Quiroga, T. Kreuz, and P. Grassberger. Event synchronization: A simple and fast method to measure synchronicity and time delay patterns. *Phys. Rev. E*, 66:041904, Oct 2002.