

Capstone Prospectus

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Course: EVSC 4995

Summary

We will be developing and testing a software package for predicting imminent regime changes in time series data using wavelet analysis. To do this, we will use simulated and empirical data from ecological systems to compare the accuracy of wavelet analysis versus current techniques.

Background

Highly connected, homogeneous systems have an innate resistance to change and ability to recover from stress back to an equilibrium. However, if external stress is too great, homogenous systems are prone to critical transitions, sharp regime shifts (Scheffer et al, 2012).

Many natural and constructed systems exhibit this same behavior, particularly ecological systems. When an ecological system approaches a regime shift, the variance of its observables and frequency of their oscillation increase. As such, using statistical analysis of ecological timeseries data, it is possible to make predictions on the likelihood of future regime shifts.

Typical techniques to accomplish this include lag-1 autocorrelation and variance analysis, but wavelet analysis could show improved accuracy in prediction. Wavelet analysis decomposes a time series into a spectral representation of the data based on a particular wavelet. The produced wavelet power function is of both time and frequency, showing how the underlying oscillations of the data are varying over time (Cazelles et al, 2014).

Methods of Analysis

We will apply wavelet analysis to simulated and empirical data, and compare the accuracy of wavelet-derived predictions versus predictions made using lag-1 autocorrelation and variance analysis. In constructing the wavelet analysis, we will need to identify indicators in the wavelet power function, and investigate the rate of change of the indicators. Additionally, we will need to determine the threshold for predicting whether or not a regime shift is imminent. This can be done with traditional hypothesis testing, but incorporating Bayesian tests will provide more informative program output.

Questions

The following are potential questions that we will seek to address in research:

1. What are the wavelet-based indicators we will use to make predictions?
2. What statistical threshold is best for predicting regime shift?
3. What statistical methods can we use to determine probability of regime shift?
4. What wavelet functions work best, and for what kind of system?
5. Can we optimize the package using simulated data?
6. Can we implement the package successfully with field data?

Deliverables

- Functions for implementing wavelet analysis
- Functions for determining and processing indicators
- A complete R-package
 - Good documentation
 - Robust function testing
- Documentation for testing and development

References

- Cazelles B, Cazelles K, Chaves M. (2014) Wavelet analysis in ecology and epidemiology: impact of statistical tests. *J. R. Soc. Interface* Vol 388 11: 20130585
- Scheffer M, Carpenter R, Lenton T, et al. (2012) Anticipating Critical Transitions. *Science Magazine* Vol 388, pg 344-348