Notes pertaining to the Granger Causality Code Pablo gave us

**What is Granger-Causality?**

A Granger causality test is a causality test from economics that uses past values of one time series to predict the future values of another time series.

Econometricians assert that Granger causality finds only “predictive causality” between these time series, rather than “true causality”. This seems to be also referred to “Granger-causality”.

A time series, X, is said to “Granger-cause” another, Y, if it can be shown that lagged values of X provide statistically significant information about the future values of Y.

**Method**

* If the time series in question is a Stationary Process (see below), the test is performed with level values of two or more variables, otherwise the test is done using first differences.
* The number of lags (see below) to be included is chosen using an information criterion (see below), typically Akaike or Schwarz.
* The criterion to retain a lagged value of one of the variables are:
  + It is significant according to a t-test
  + An F-test indicates that it adds explanatory power to the model when paired with other retained values.
* The null hypothesis of there being no Granger causality between the variables in question is not rejected **if and only if** no lagged values of the explanatory variable are retained in the regression.

**Stationary Process**

A stationary process is defined as a stochastic process whose joint probability distribution does not change when shifted in time.

For illustrative examples, a white noise signal would be said to be a stationary process, as its general distribution isn’t affected by shifts in time. Alternatively, a signal originating from a cymbal crash would not be said to be stationary, as its signal strength diminishes over time.

**Lag Operator**

The Lag Operator operates on an element of a time series to produce the previous element in the series.

Lag(Xt) = Xt-1

Thename for the product of the Lag Operator is a **Lag**.

**Information Criterions**

Information Criterion functions are used to measure the relative quality of a statistical model of a given data set. Schwarz models are Bayesian in nature, whereas Akaike’s model is founded in information theory.

**Limitations:**

* Granger-Causality is not necessarily true causality.
* The original Granger test is designed to handle pairs of variables, and may produce misleading results when the true relationship involves three or more variables.

**So what’s this all mean?**

From what I’ve read, generally speaking, the question we’d want to be asking here is if a time-series describing the movement of the trunk marker is useful in predicting future values of the movement of the arm marker.

It seems that utilizing Granger-Causality measures here is a defensible tactic; however, it is worth bearing in mind that the original definition of Granger-Causality does not account for latent confounding effects and does not capture instantaneous or non-linear causal relationships. It may be the case that Barnett and Seth’s MVGC toolbox may implement one of several extensions proposed to address such issues.

The primary question is whether or not Dr. Rachwani feels that the movement of the trunk and arm are, mathematically speaking, stationary processes.

**Author’s Warnings**

1. The Authors highly recommend consulting their reference document when using the demo to design your code implementation of the Multivariate Granger-Causality toolbox.
   1. Particularly Section 3
2. The Authors indicate that one should **NOT** pre-filter data prior to Granger-Causality estimation, unless the filtration improves the stationarity of the data. Examples given are notch-filtering line noise from the data, or high-pass filtering to suppress low-frequency transients.
   1. Pre-filtration of stationary data may serious degrade Granger-causal inference.
   2. The Authors suggest that if one wants to determine Granger-causality over a limited frequency range, to perform a Granger-causality analysis over the full frequency range, and then integrate over the desired frequency band.
3. The toolbox is dependent on the MATLAB Statistics being available and installed.
4. The MVGC can be acquired at: <http://www.sussex.ac.uk/sackler/mvgc/>

**Copyright Terms**

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**References:**

1. <http://en.wikipedia.org/wiki/Granger_causality>
2. <http://en.wikipedia.org/wiki/Stationary_process>
3. <http://en.wikipedia.org/wiki/Lag_operator>
4. <http://en.wikipedia.org/wiki/Bayesian_information_criterion>
5. http://en.wikipedia.org/wiki/Akaike\_information\_criterion
6. L. Barnett and A.K. Seth, <http://www.sciencedirect.com/science/article/pii/S0165027013003701> The MVGC Multivariate Granger Causality Toolbox: A New Approach to Granger-Causal Inference, J. Neurosci. Methods 223, 2014
7. A.B. Barrett, L Barnett and A.K. Seth, “Multivariate Granger Causality and Generalized Variance”, Phys. Rev. E 81(4), 2010.
8. L. Barnett and A.K. Seth, “Behaviour of Granger Causality under filtering: Theoretical invariance and practical application”, J. Neurosci. Methods 201(2), 2011
9. <http://www.gnu.org/licenses/quick-guide-gplv3.html>