The Multi-Event-Class Synchronization (MECS) Algorithm

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Background

- *Event Synchronization* (ES) measures synchronization and time-delay patterns between events occurring in a collection of time series.
- *Events* consist of the detection of significant behaviors of the system under observation.
- ES was initially proposed by Quian Quiroga et al. (2002) who applied it to two time series.
- The technique was originally developed to study brain signals, but it found applications in other domains, including human-machine interaction, analysis of group dynamics, and inter/intra-personal coordination.

Objective

- Extending existing ES techniques, by enabling:
  - Multiple time-series
  - Multiple classes of events
  - Macro events
  - Macro classes

Reference	Number of		Macro	
	time series	classes	events	classes
Quian Quiroga et al., 2002	2	1	Not handled	Not handled
Iqbal and Riek, 2016	M	N	Not handled	Not handled
Kreuz et al., 2009	M	1	Not handled	Not handled
MECS	M	N	Handled	Handled

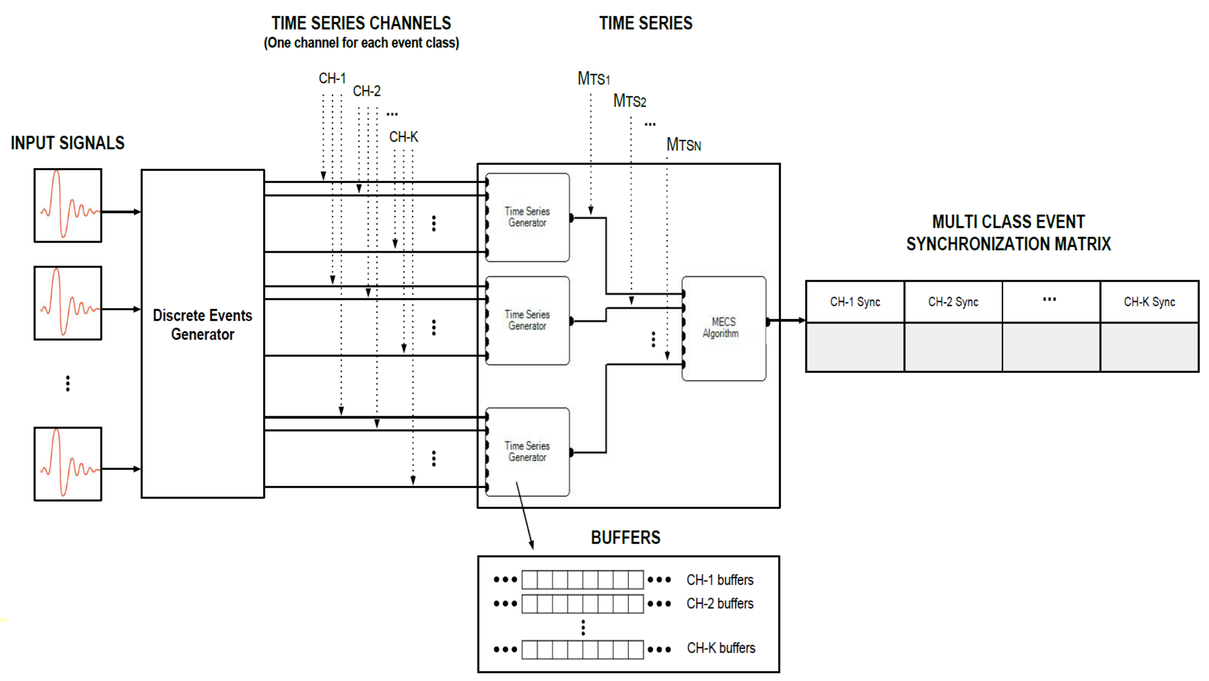
Algorithm

- Given a collection of time series and events belonging to different classes, MECS computes:
  - Synchronization within each class of events (*intra-class synchronization*).
  - Synchronization between classes of events (*inter-class synchronization*).
  - A *global synchronization index* for all classes.
- The computation consists of two steps:
  1. The algorithm detects coincidences of events in two different time series and in a specific time interval (*coincidence detection*) and counts them.
  2. The number of detected coincidences is normalized with respect to the total number of possible coincidences (*normalization*).

Macro classes and macro events

- Classes can be grouped into *macro classes*. MECS considers each item of the classes composing a macro class as belonging to the same class.
- Events can be grouped into *macro events*, i.e., specific aggregations of events defined by a set of constraints. An example of a macro-event is a *sequence of events*, where the constraint to be satisfied is the order of occurrence of each event in the sequence.

Implementation



- An implementation of MECS is available in EyesWeb.

Example

- Multi-modal intra-personal synchronization between respiration and kinetic energy of a professional dancer performing impulsive vs. fluid body movements.
- *Data*: audio of the respiration (microphone) and acceleration of the hands (accelerometers).
- *Events*: peaks of respiration energy and kinetic energy.
- *Results*:
  - *Impulsive movements*: synchronization scores are similar for inspiration (0.58) and expiration (0.65).
  - *Fluid movements*: only few synchronized events observed for inspiration (0.12) and expiration (0.04).

References

- Tariq Iqbal and Laurel D. Riek. 2016. A Method for Automatic Detection of Psychomotor Entrainment. IEEE Transactions on Affective Computing 7, 1, 3–16.
- Thomas Kreuz, Daniel Chicharro, Ralph G. Andrzejak, Julie S Haas, and Henry DI Abarbanel. 2009. Measuring multiple spike train synchrony. Journal of neuroscience methods 183, 2, 287–299.
- Rodrigo Quian Quiroga, Thomas Kreuz, and Peter Grassberger. 2002. Event synchronization: a simple and fast method to measure synchronicity and time delay patterns. Physical review E 66, 4, 041904.

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