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pyMannKendall: a python package for non parametric Mann Kendall family of trend tests.

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Summary

Trend analysis is one of the most important measurements in studying time series data. Both parametric and non-parametric tests are commonly used in trend analysis. Parametric tests require data to be independent and normally distributed. On the other hand, non-parametric trend tests require only that the data be independent and can tolerate outliers in the data (Hamed & Rao, 1998). However, parametric tests are more powerful than nonparametric ones.

The Mann–Kendall trend test (Kendall, 1975; Mann, 1945) is a widely used non-parametric tests to detect significant trends in time series. However, the original Mann-Kendall test didn't consider serial correlation or seasonality effects (Bari, Rahman, Hoque, & Hussain, 2016; Hirsch, Slack, & Smith, 1982). But, in many real situations, the observed data are autocorrelated and this autocorrelation will result in misinterpretation of trend tests results (Cox & Stuart, 1955; Hamed & Rao, 1998). Contrariwise, water quality, hydrologic, as well as climatic and other natural time series also have seasonality. To overcome those limitations of original Mann-Kendall test, various modified Mann-Kendall test have been developed.

Again, Python is one of the widely used tools for data analysis. A large number of data analysis and research tools are also developed using Python. But, till now, there is no Mann-Kendall trend relation Python package available. `pyMannKendall` package fills this gap.

`pyMannKendall` is written in pure Python and uses a vectorization approach to increase its performance. Currently, this package has 11 Mann-Kendall Tests and 2 Sen's slope estimator functions. Brief description of the functions are below:

1. **Original Mann-Kendall test (*original_test*):** Original Mann-Kendall test (Kendall, 1975; Mann, 1945) is a nonparametric test, which does not consider serial correlation or seasonal effects.
2. **Hamed and Rao Modified MK Test (*hamed_rao_modification_test*):** This modified MK test was proposed by Hamed & Rao (1998) to address serial autocorrelation issues. They suggested a variance correction approach to improve trend analysis. Users can consider first n significant lag by insert lag number in this function. By default, it considered all significant lags.
3. **Yue and Wang Modified MK Test (*yue_wang_modification_test*):** This is also a variance correction method for considered serial autocorrelation proposed by Yue & Wang (2004). Users can also set their desired significant number of lags for the calculation.
4. **Modified MK test using Pre-Whitening method (*pre_whitening_modification_test*):** This test was suggested by Yue & Wang (2002) to use Pre-Whitening the time series before the application of trend test.

5. **Modified MK test using Trend free Pre-Whitening method (*trend_free_pre_whitening_m*** This test was also proposed by Yue, Pilon, Phinney, & Cavadias (2002) to remove trend components and then Pre-Whitening the time series before application of trend test.

6. **Multivariate MK Test (*multivariate_test*):** This is an MK test for multiple parameters proposed by Hirsch et al. (1982). They used this method for seasonal MK tests, where they considered every month as a parameter.

7. **Seasonal MK Test (*seasonal_test*):** For seasonal time series data, Hirsch et al. (1982) proposed this test to calculate the seasonal trend.

8. **Regional MK Test (*regional_test*):** Based on the proposed seasonal MK test of Hirsch et al. (1982), Helsel & Frans (2006) suggest a regional MK test to calculate the overall trend on a regional scale.

9. **Correlated Multivariate MK Test (*correlated_multivariate_test*):** This multivariate MK test was proposed by Hipel & McLeod (1994) for where the parameters are correlated.

10. **Correlated Seasonal MK Test (*correlated_seasonal_test*):** This method was proposed by Hipel & McLeod (1994), for when time series significantly correlate with the preceding one or more months/seasons.

11. **Partial MK Test (*partial_test*):** In a real event, many factors affect the main studied response parameter, which can bias the trend results. To overcome this problem, Libiseller & Grimvall (2002) proposed this partial mk test. It required two parameters as input, where one is the response parameter and other is an independent parameter.

12. **Theil-sen's Slope Estimator (*sens_slope*):** This method was proposed by Theil (1950) and Sen (1968) to estimate the magnitude of the monotonic trend.

13. **Seasonal sen's Slope Estimator (*seasonal_sens_slope*):** This method was proposed by Hipel & McLeod (1994) to estimate the magnitude of the monotonic trend, when data has seasonal effects.

`pyMannKendall` is a non-parametric Mann-Kendall trend analysis package implemented in pure Python, which brings together almost all types of Mann-Kendall tests, which might help researchers to check Mann-Kendall trends in Python.

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