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ppdiag: Diagnostic Tools for Temporal Point Processes

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Software

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Summary

Temporal Point Processes are widely used to model phenomena in many fields, such as finance and neuroscience. However, tools to evaluate the fit of these point processes to data, and to identify reasons for lack of fit, are not readily implemented in common software. Here we provide `ppdiag`, an `R` package containing a selection of statistically motivated tools to analyse the goodness of fit of point processes to data, as have been utilised in Wu, Smith, & Zheng (2020).

Statement of Need

This package provides functions to evaluate the fit of univatiate temporal point processes. Existing functions aim at:

- Simulating data from a range of common univariate point processes including Homogeneous Poisson Process, Hawkes Process, and Markov-modulated Hawkes Process.
- Fitting a range of univariate point processes to data, and plotting the intensity function over data.
- After fitting a point process model to data, evaluating the ability of that model to capture the temporal structure present in data. Methods for diagnostics include raw and Pearson residuals, Kolmogrov-Smirnov test and plot, and Q-Q plot.

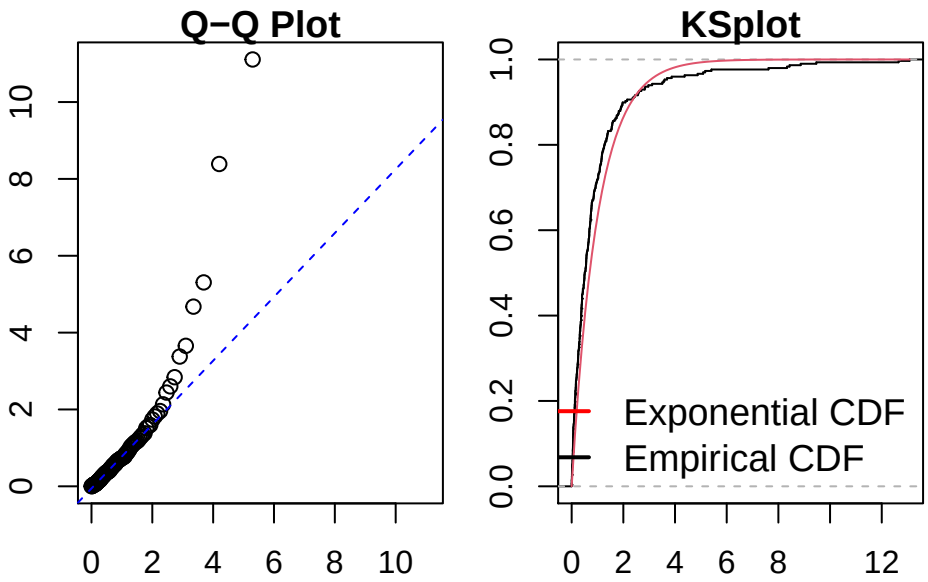
Demonstration

We illustrate the use of this functionality with a simple example of readily available email data (Çetinkaya-Rundel et al., 2020).

```
library(ppdiag)
library(openintro)
library(lubridate)
first <- ymd_hms(email$time[1],tz="EST")
second <- ymd_hms(email$time[2],tz="EST")
time <- (as.duration(interval(first,
                    ymd_hms(email$time[-1],tz="EST")))/3600)[1:300]
time_data <- sort(unique(time))
```

We can fit a homogeneous Poisson process and look at the goodness of fit of this model to the data.

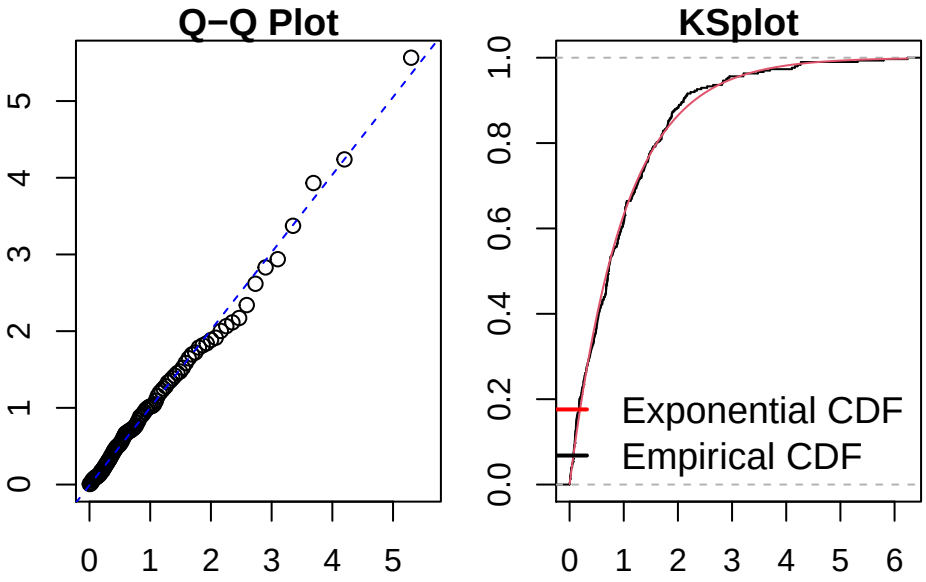
```
email_hpp <- fithpp(time_data)
diagpp(email_hpp, events = time_data)
```




```
#>
#> Raw residual: 298
#> Pearson residual: -0.8935674
#>
#>  One-sample Kolmogorov-Smirnov test
#>
#> data:  r
#> D = 0.12391, p-value = 0.0002123
#> alternative hypothesis: two-sided
```

Similarly, we can fit a self exciting Hawkes process to this data and examine the results of that fit.

```
email_hp <- fithp(events = time_data)
diagpp(email_hp, time_data)
```

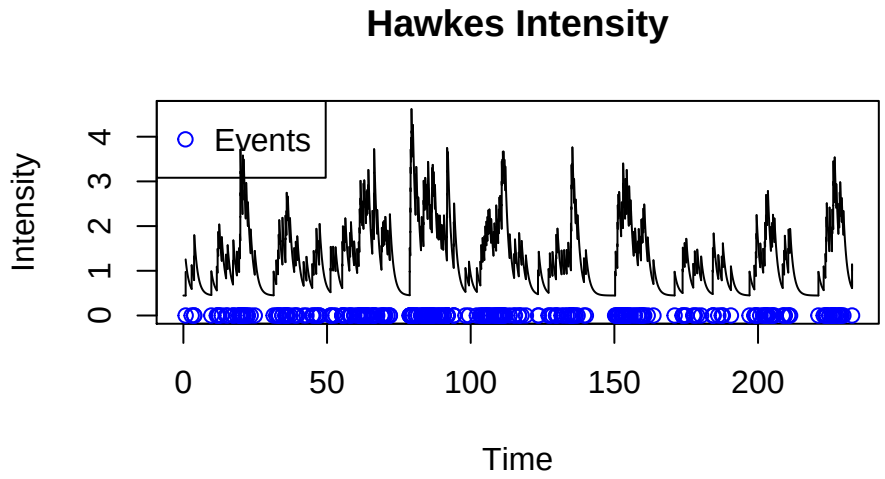



```
#> Raw residual: 0.0001270847
#> Pearson residual: 1.560215
#>
#>  One-sample Kolmogorov-Smirnov test
#>
#> data:  r
#> D = 0.041649, p-value = 0.6795
#> alternative hypothesis: two-sided
```

Examining the results of the Kolmogrov-Smirnov test, based on the time rescaling theorem (Brown, Barbieri, Ventura, Kass, & Frank, 2002), indicates that a Hawkes process better describes these events.

We can then examine the estimated intensity of this Hawkes process to this data.

```
drawHPIntensity(email_hp, events = time_data,
                plot_events = TRUE)
```



References

Brown, E. N., Barbieri, R., Ventura, V., Kass, R. E., & Frank, L. M. (2002). The time-rescaling theorem and its application to neural spike train data analysis. *Neural computation*, *14*(2), 325–346.

Çetinkaya-Rundel, M., Diez, D., Bray, A., Kim, A., Baumer, B., Ismay, C., & Barr, C. (2020). *Openintro: Data sets and supplemental functions from 'openintro' textbooks and labs*. Retrieved from https://CRAN.R-project.org/package=openintro

Wu, J., Smith, A. L., & Zheng, T. (2020). Diagnostics and visualization of point process models for event times on a social network. *arXiv preprint arXiv:2001.09359*.