Usage of rpp functions

This document provide an example of using the functions in rpp.R to fit a citation curve, following the model proposed in Wang, Song, and Barabasi (2013).

0.1 Usage of main function

First source the **rpp.R** file

```
source('rpp.R')
```

The main function is `fitRPP(citation.times, ...)`, where `citation.times` is a vector $\{t_i\}_{i=1}^n$ of the time each citation is recieved by the paper, which is recorded by number of days after the paper was published.

For example, a paper X was published in 2000.01.01, then it received the first citation 50 days after publication, and the second citations arrived 75 days later, and so on. If the papers has received n citations until the give time T then `citation.times`$= (50, 75, ...t_n)$.

Input parameters:

- `citation.times`: a vector indicating the arriving time of each citation $\{t_i\}_{i=1}^n$
- `m`: (optional) the global constant, suggested m = 30 by the science paper, as the defalt.
- `time.T` (optional) the observation time $[0, T]$, so that $0 \leq t_1 \leq t_2 \leq \ldots \leq t_n \leq T$. If not given, use the last citation arriving time as T, so that $T = t_n$.
- `verbose` (optional) boolean, whether to output esitmation at each step, by default is False.
- `mu.init` (optional) the initial value of μ.
- `sigma.init` (optional) the initial value of σ.
- `max.iter` (optional) the maximum number of iteration in gradient descent, by default 1000.
- `eps` (optional) tolerance using in stopping criteria, by default $10^{(-8)}$.

Output:

A list containing the estimated parameters `mu`, `sigma`, `lambda` $= \hat{\mu}, \hat{\sigma}, \hat{\lambda}$ and `converge` shows whether the optimization converges before it reaches `max.iter` iterations.

```
fit = fitRPP(citation.times, m = 30, time.T = 10*365)
```

0.2 Example

Here we generate citations of a paper following the model in Wang, Song, and Barabasi (2013). Given parameter (λ, μ, σ), the accumulative citation counts $c(t)$ follows

$$c(t) = m(e^{\lambda F(t;\mu,\sigma)} - 1)$$

where $F(t; \mu, \sigma) = \int_0^t f(x; \mu, \sigma)dx$ and $f(x, \mu, \sigma)$ is a log normal density function with mean μ sd σ, m is a global constant, suggested as 30 by the paper.

```
# generate the citation times of the paper,
# that happen within 10 years (10 * 365 days)
time.T = 10 * 365
citation.time.example = citationGenerator(time.T = time.T , lambda = 3,
                                          mu = 7, sigma = 1, m = 30)
(n = length(citation.time.example)) # number of citations received in [0, time.T]
```

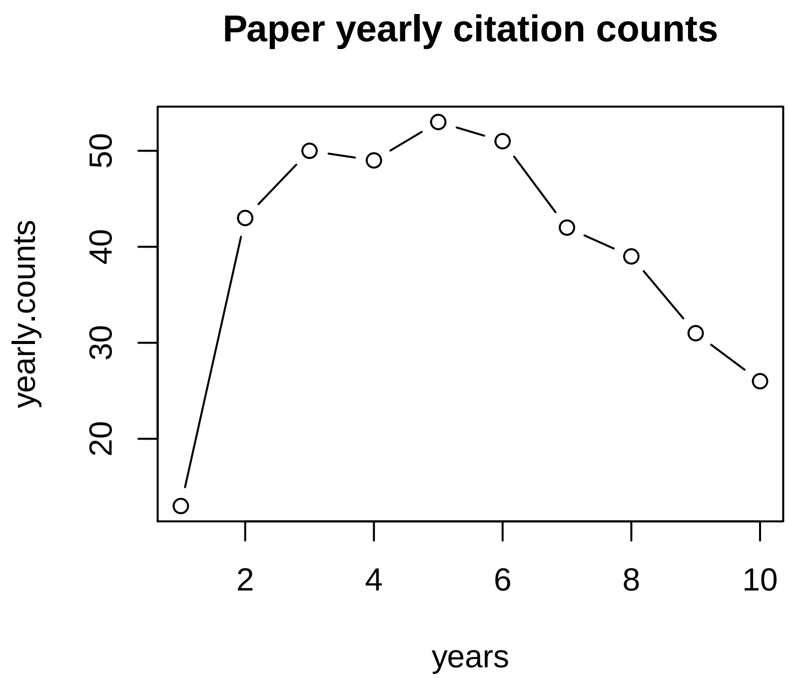
```
## [1] 397
```

Then add some noise

```
citation.time.example = citation.time.example + rnorm(n, 0,50)
citation.time.example[citation.time.example < 1] = 1
citation.time.example[citation.time.example > time.T ] = time.T
citation.time.example = sort(citation.time.example, decreasing = F)
```

Count the yearly citations

```
# the function count the citations per year
yearly.counts = citationYearlyCount(citation.time.example)
plot(yearly.counts, type = 'b', xlab = 'years',
     main = 'Paper yearly citation counts')
```



Then fit RPP model to estimate the parameters

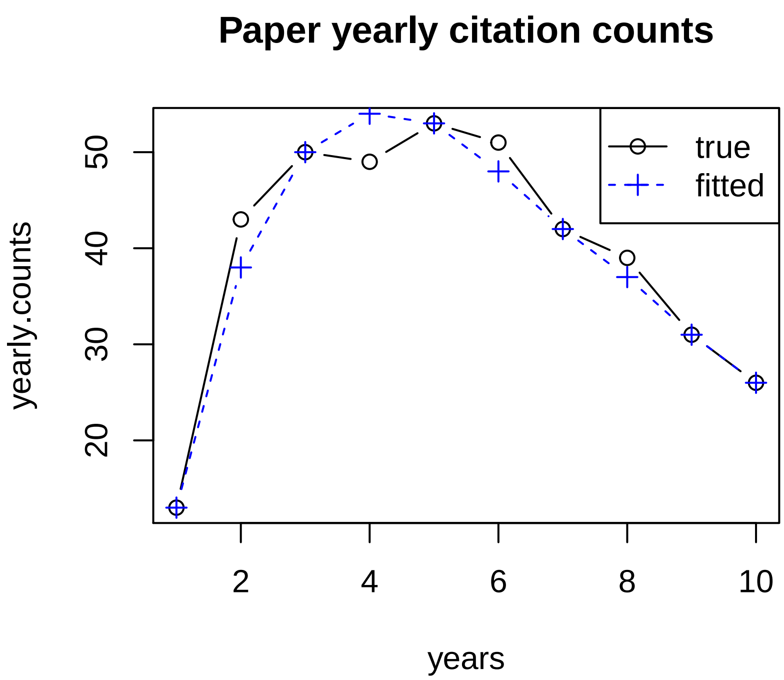
```
fit = fitRPP(citation.time.example, time.T = 10 * 365)
fit
```

```
## $mu
## [1] 7.004268
##
## $sigma
## [1] 0.96836
##
## $lambda
## [1] 2.965058
##
## $converge
## [1] TRUE
```

Plot the fitted curve on top of the yearly citations

```
fitted.citation = citationGenerator(time.T = 10 * 365, lambda = fit$lambda,
                                    mu = fit$mu, sigma = fit$sigma, m = 30)
fit.yearly.counts =  citationYearlyCount(fitted.citation)
```

```
plot(yearly.counts, type = 'b',col = 'black', xlab = 'years',
     main = 'Paper yearly citation counts')
points(fit.yearly.counts, col = 'blue', lty = 2, type = 'b',pch = 3)
legend('topright', legend=c('true', 'fitted'),
        col = c('black','blue'), lty = 1:2, pch = c(1,3))
```



Reference

Wang, D. S., C. M. Song, and A. L. Barabasi. 2013. "Quantifying Long-Term Scientific Impact." Journal Article. *Science* 342 (6154): 127–32. doi:10.1126/science.1237825.