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A Signal Detection from Noise Using R

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ABSTRACT: Noise is the unwanted energy that interferes with the ability of the receiver to detect the wanted signal. It may enter through the antenna along with the desired signal or it may be generated within the receiver itself. In underwater sonar systems, external acoustic noise is generated by waves and wind on the water surface, by biological agents (fish, prawns, etc.), and by man-made sources such as engine noise. In radar and lidar sensors the external electromagnetic noise is generated by various natural mechanisms such as the sun and lightning, among others. Man-made sources of electromagnetic noise are myriad, from car ignition systems and fluorescent lights to other broadcast signals. The deliberate transmission of noise in an attempt to mask a target echo or otherwise deceive a sensor is known as jamming.

KEYWORDS: Signal detection, Noise, MARSS, Jamming.

I. INTRODUCTION

The term "signal" actually has two meanings: in the more general sense, it can mean the *entire* data recording, including the noise and other artefacts, as in the "raw signal" before processing is applied. But it can also mean only the *desirable* or *important* part of the data, the *true underlying signal* that you seek to measure. A fundamental problem in signal measurement is distinguishing the true underlying signal from the noise. So, for measuring signal first we need to detect our target signal from the noisy sensors. The sensors an AR-1 error model which is a good approximation: $y_t = a + e_t$ where a is our signal and $e_t = be_{t-1} + wt$. w_t is white noise with some unknown standard deviation and mean 0.

Paper is organized as follows. Section II describes the procedures that has to be done in order to detect a signal using R coding. Section III describes the R codes that has been used. Section IV shows the results. Finally, Section V presents conclusion.

II. PROCEDURES

Firstly, we need to pick up the signal and separate it from the noise added by our sensors. We have measured a signal that has a local noisy component (from say local winds or currents or something). That noise might be autoregressive (temporally correlated) because whatever we are measuring is temporally correlated (like temperature).

Then we need to create a data and plot it and the error added to the signal by each sensor. The errors are AR-1. For this we need to create a model and also to fit it through MARSS (). Then we need to estimate the common trend from model and then has to compare with the mean of the data. Then, we see that for the missing data, no signal to be seen.

For performing all the above we need packages:-

```
library(ggplot2)
library(MARSS)
library(stringr)
set. Seed(1234)
```

III. R CODES

R codes to perform all operations are:-

```
#to create a signal:- arima.sim()
#to smoothen a signal:-filter()
#to plot the data:-
p1 <-ggplot(subset(df, name != "signal"), aes(x = t, y =val)) +
```



```
geom_line() +facet_wrap(~name, ncol =2)
p1
#for model:-
makemod<-function(n) {
  B <-matrix(list(0), n +1, n +1)
diag(B)[2:(n +1)] <-paste0("b", 1:n)
  B[1, 1] <-1
  A <-"zero"
  Z <-cbind(1, diag(1, n))
  Q <-matrix(list(0), n +1, n +1)
  Q[1, 1] <-1
diag(Q)[2:(n +1)] <-paste0("q", 1:n)
  R <-"zero"
  U <-"zero"
  x0 <-"zero"
mod.list<-list(B = B, A = A, Z = Z, Q = Q, R = R, U = U,
x0 = x0, tinitx =0)
return(mod.list)
}
mod.list1 <-makemod(3)
```

#to demean the data:-

```
dat2 <-dat-apply(dat, 1, mean) %*%matrix(1, 1, TT)
```

#to fit:-

```
fit.mod1 <-MARSS(dat2, model = mod.list1)
#to show the fits:-
require(ggplot2)
autoplot(fit.mod1, plot.type ="xtT", conf.int =FALSE)
```

to estimate the common trend from model, then to compare with the mean of the data and for missing data, the codes are provides below:-

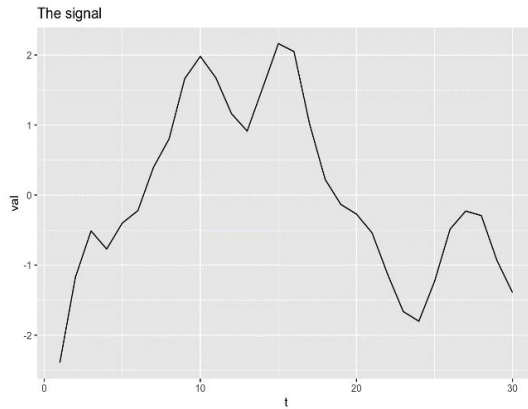


R CODES.R

IV. EXPERIMENTAL RESULTS

Figures shows the results of signal detection from noise:-

- (a). signal create (b). Data create (c). Model fit (d).fits (e).estimated common trend. (f).comparison between trend and mean of the data. (g).-(j) missing data and fits.



Figure(a):- Signal create

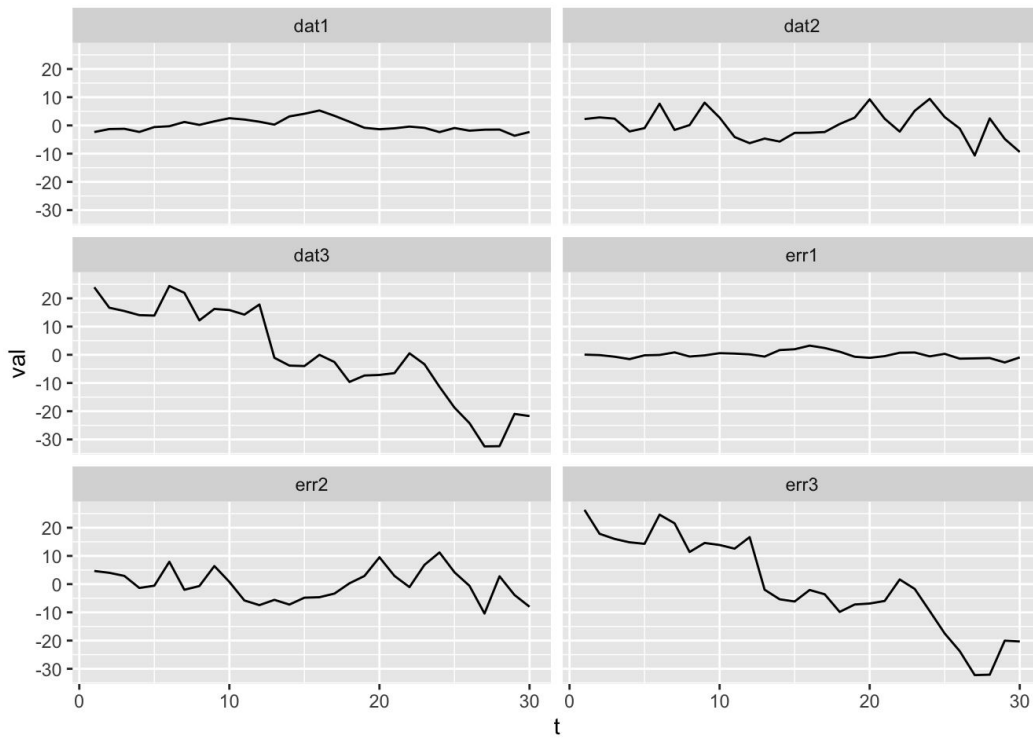


Figure (b):- Data create

Success! algorithm run for 15 iterations. abstol and log-log tests passed.
Alert: conv.test.slope.tol is 0.5.
Test with smaller values (<0.1) to ensure convergence.

MARSS fit is
Estimation method: kem
Convergence test: conv.test.slope.tol = 0.5, abstol = 0.001
Algorithm ran 15 (=minit) iterations and convergence was reached.
Log-likelihood: -244.5957
AIC: 501.1914 AICc: 502.2035

Estimate

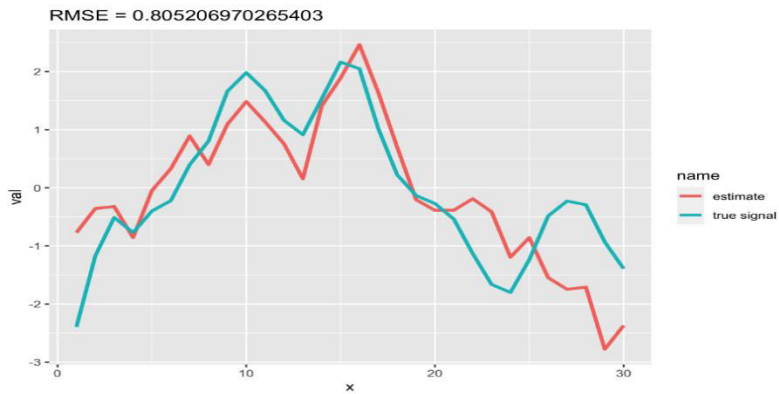


B.b1 0.790
 B.b2 0.406
 B.b3 0.905
 Q.q1 1.004
 Q.q2 23.042
 Q.q3 55.892

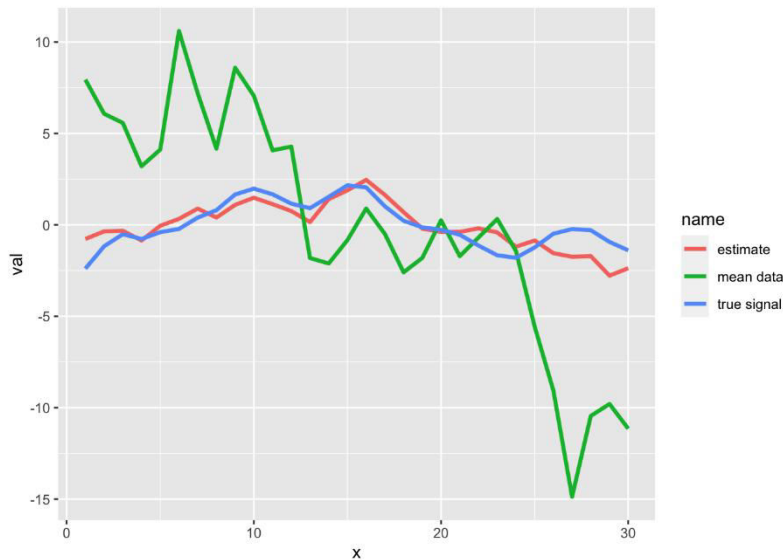
Initial states (x0) defined at t=0
 Standard errors have not been calculated.

Use MARSSparamCIs to compute CIs and bias estimates

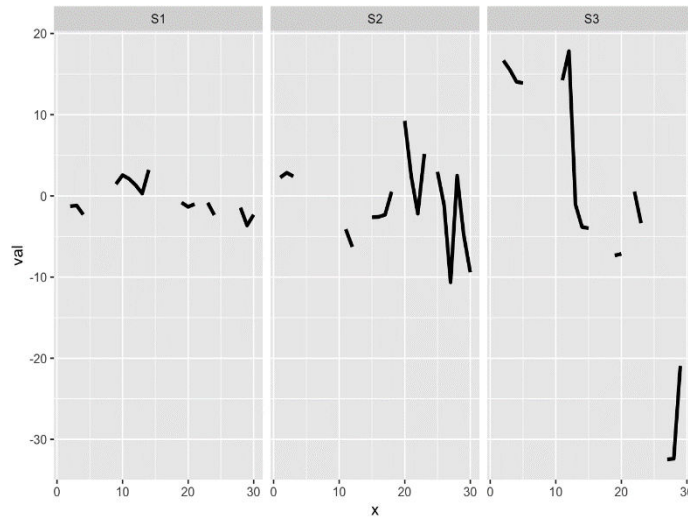
Figure(c):- Model fit result



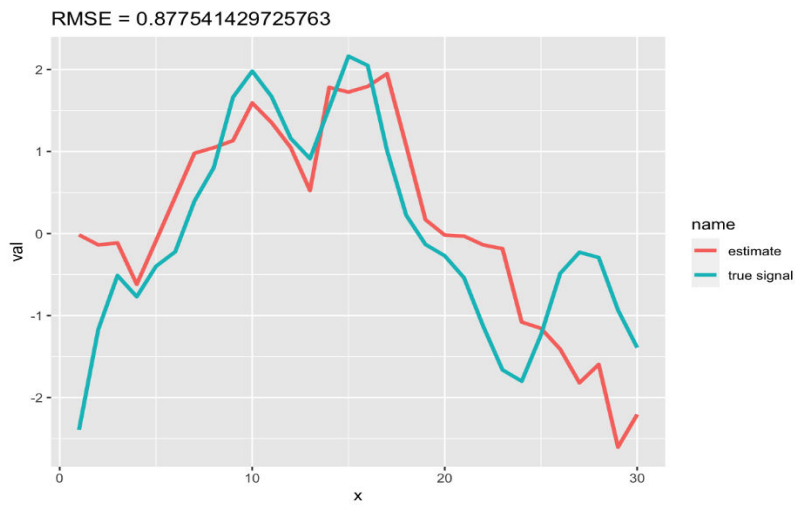
Figure(d):-fits



Figure(e):-estimatedcommon trend



Figure(f):- Missing data(1)



Figure(g):-fit(1a)

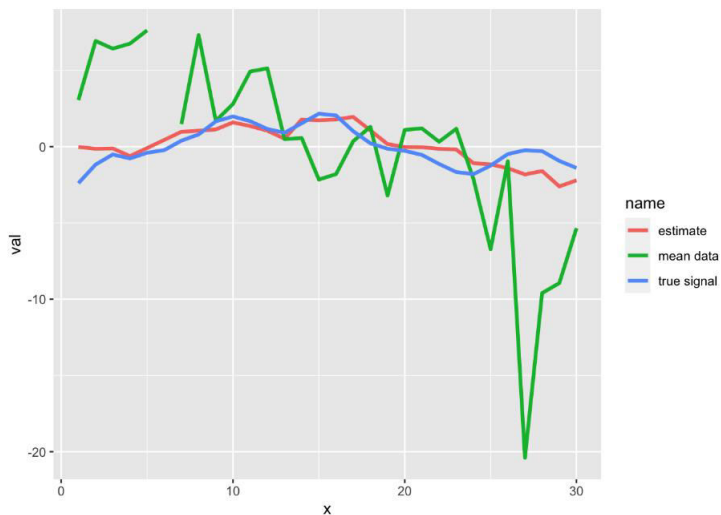
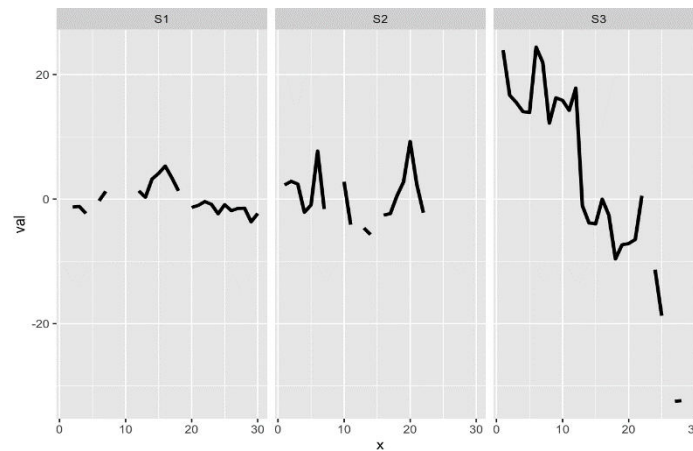
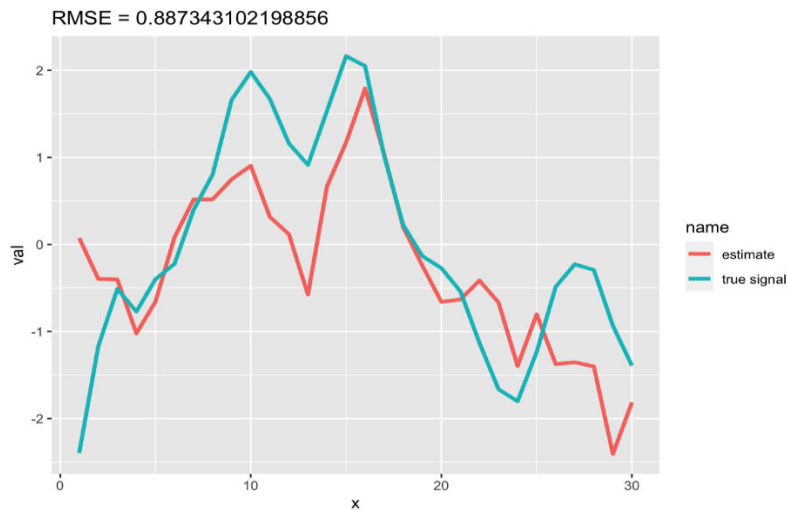


Figure (h):-fit(1b)



Figure(i):-Missing data(2)



Figure(j):-fit(2)

V. CONCLUSION

We have implemented a signal detection from noise using R programming. Our algorithm successfully detects the signal which is the estimated one.

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