732A62 Time Series Analysis
Division of Statistics and Machine Learning
Department of Computer and Information Science

Computer lab 3

Instructions

- The lab is assumed to be done in groups.
- Create a report to the lab solutions in PDF.
- Be concise and do not include unnecessary printouts and figures produced by the software and not required in the assignments.
- **Include all your codes as an appendix into your report.**
- A typical lab report should 2-4 pages of text plus some amount of figures plus appendix with codes.
- The group lab report should be submitted via LISAM before the deadline.
- Use 12345 as a random seed everywhere where the result of the simulation differs with the run unless stated otherwise.

Assignment 1. Spectral analysis of the chicken prices

1. Plot a time series *chicken* (denote it by x_t) provided in the library *astsa*. Suggest by visual inspection what kind of trend seems to be reasonable – linear, quadratic or a higher order polynomial.
2. Perform detrending of x_t by doing a linear regression of x_t versus t, transform the residuals to a time series object and plot them afterwards. Do these residuals seem to be stationary? Denote the detrended data as z_t.
3. Compute the periodogram for z_t by applying a Fast Fourier transform and plot the perodogram. Which frequencies do visually seem to be dominant frequencies (i.e. not noise)? Decide on a baseline level I_0 such that the dominant frequencies satisfy $I(\omega) > I_0$. Compute a confidence interval for the frequency with the highest amplitude and compare its lower bound with I_0. Conclusions?
4. Use the frequencies that satisfy $I(\omega) > I_0$ to manually implement the Inverse Fourier transform (set the remaining frequencies equal to zero) and obtain a filtered data and 36 step ahead predictions. Add up predictions from the linear function obtained at step 2 and present data x_t, the filtered data and the forecasts in one plot. Compare the original data and the filtered data. Does the forecast look reasonable – why or why not?
5. Compute a smoothed spectrum of z_t by applying a non-parametric spectral estimation with $ModifiedDaniell(2,2)$. Write a code to compute lower and upper confidence limits for each frequency value. Present the smoothed periodogram, lower and upper confidence bands into one plot. Decide on a frequency w_0 such that the lower limit curve for $I(w_0)$ is just above the noise level of the spectrum. Compare the frequencies extracted by the rule $w < w_0$

with the frequencies that were extracted at step 4. Did smoothing help much for these data to discover the important frequencies?

6. Fit x_t with $ARIMA(2,1,0)\times(0,0,1)_{12}$. Does this model seem to be suitable according to the diagnostic plots? Compute and plot 36 steps ahead prediction and compare it to the Fourier analysis prediction from step 4. Which prediction would you trust more and why?
7. Fit z_t with $ARIMA(3,0,0)\times(0,0,1)_{12}$. Does this model seem to be suitable according to the diagnostic plots? Compute the spectral density of the fitted ARIMA model and present the plot showing the spectrum. Compare the plot with the smoothed periodogram from step 5 and make conclusions.

Assignment 2. GARCH modeling of the oil prices.

In this assignment, you shall study data the changes of the oil prices $x_t = \nabla\log(oil)$ where oil is a data set located in the library $astsa$.

1. Consider data z_t to be a subset of x_t containing all observations up to 33rd week of 2009. Suggest one ARMA model (non-seasonal one, as simple as possible) that fits z_t reasonably well. Motivate your choice by standard diagnostic plots and by coefficient significance. Denote residuals from this model as r_t, and the orders selected as p,q
2. Plot r_t and comment whether non-constant variance assumption is reasonable. Study also ACF and PACF of r_t^2 and choose preliminary orders for a $GARCH$ model.
3. Use information from the previous step to select a suitable $ARMA(p,q) - GARCH(p',q')$ model for z_t. When doing model selection, study Standardized Residuals Plot, ACF Plot of Standardized Residuals, ACF Plot of Squared Standardized Residuals, Quantile-Quantile Plot of Standardized Residuals, significance of the coefficients, Jarque-Bera Test, Ljung-Box Test, AIC and BIC. Present you analysis of these diagnostic measures for the final model only. Report the equation of the fitted $GARCH(p',q')$ part of the model.
4. Present z_t and the predicted volatility in one plot. Does the predicted volatility pattern seem to follow the variation of the data?
5. Simulate 500 observations from the model fitted at step 3. Plot the resulting series and compare it to z_t – are their patterns similar?
6. Compute and plot 45 step ahead predictions from the obtained $ARMA(p,q) - GARCH(p',q')$, plot also x_t and compare these two plots. How well does the prediction band capture the future data?