Lab 6 - MA and AR model correlations

Preparing data and pipeline for AR(2) fitting.

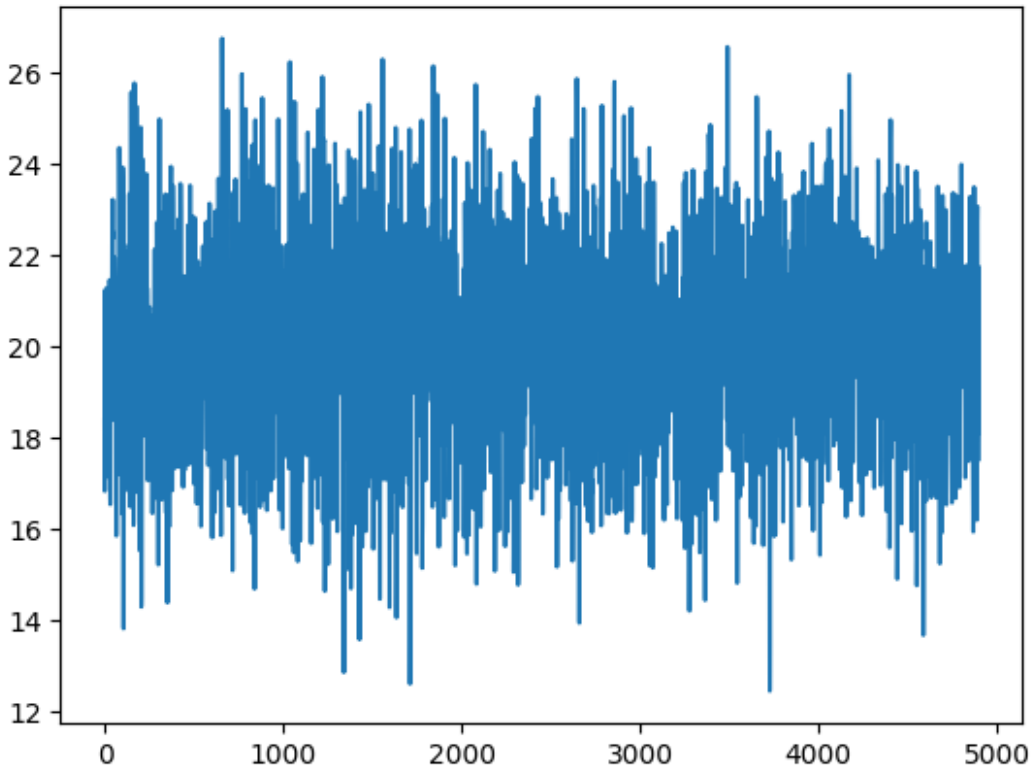
First I will copy my AR(p) and MA(p) functions.

```
def generate_ar_model(c, phi_values, epsilon_values, burnin):
    """
    plot to generate ar_model y values
    """
    ar_values = [0]*len(phi_values)  # fill with zeroes to not make it
go out of index?
    for t in range(len(phi_values), len(epsilon_values)):
        ar_value = c + epsilon_values[t] +
sum(phi_values[i]*ar_values[t-i-1] for i in range(len(phi_values)))
        ar_values.append(ar_value)
    return ar_values[burnin:]
```

Now I will recreate AR model.

```
import numpy as np
import matplotlib.pyplot as plt
# noise
random_values_5k = np.random.normal(0, 1, 5000)
# create AR 2 model
ar_model_2 = generate_ar_model(8, [1.3, -0.7], random_values_5k, 100)
plt.plot(ar_model_2)
```

```
[<matplotlib.lines.Line2D at 0x2743ead0650>]
```



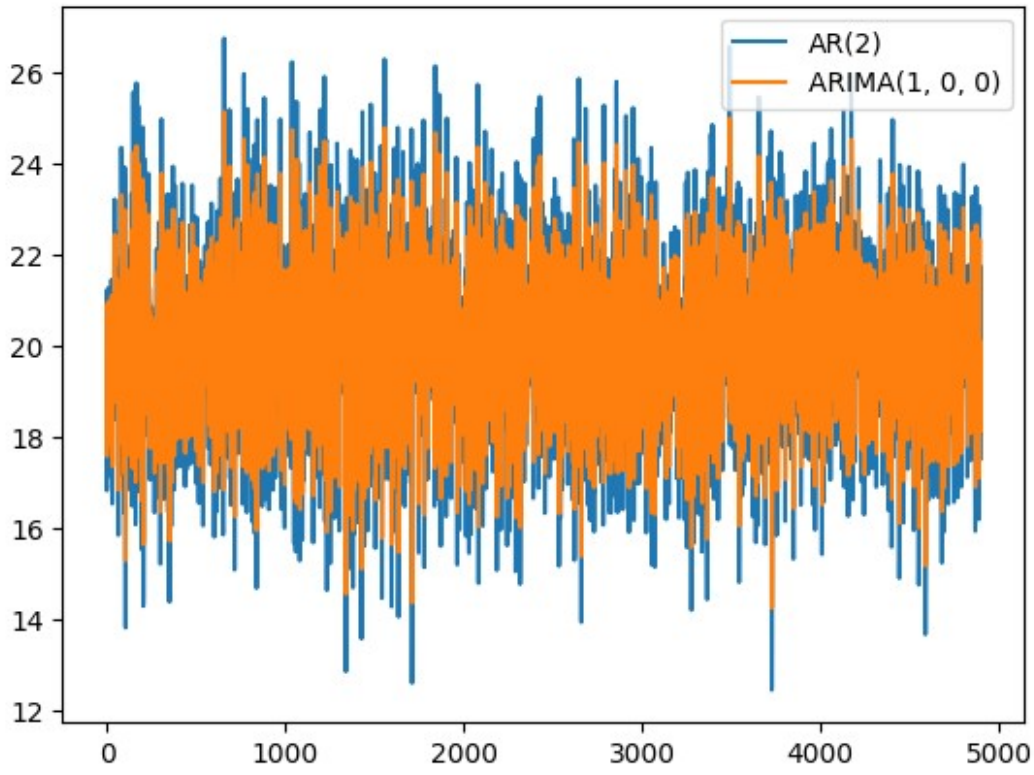
Now I will try to fit sequence of ARIMA models to this AR(2) model. To perform those tests I will use this simple pipeline.

```
from statsmodels.tsa.arima.model import ARIMA
def arima_fit_and_present(ar_model, arima_num):
    best_aic = np.inf
    best_bic = np.inf

    arima_model = ARIMA(ar_model, order=(arima_num, 0, 0))
    model_fit = arima_model.fit()

    plt.plot(ar_model, label='AR(2)')
    plt.plot(model_fit.fittedvalues, label=f'ARIMA({arima_num}, 0,
0)')
    plt.legend()
    plt.show()

    arima_model_AIC = round(model_fit.aic,5)
    arima_model_BIC = round(model_fit.bic,5)
    print(f'for Arima model {arima_num} fit  AIC is {arima_model_AIC},
BIC is {arima_model_BIC}')

    return model_fit, arima_model_AIC, arima_model_BIC

from scipy.stats import chi2
```

```
def perform_llrt(model_fit_1, model_fit_2):
    # Calculate the Log-Likelihood Ratio Test
    lr_stat = -2 * (model_fit_1.llf - model_fit_2.llf)

    # Calculate the degrees of freedom
    df = model_fit_2.df_model - model_fit_1.df_model

    # Calculate the p-value
    p_value = chi2.sf(lr_stat, df)

    print(f"Likelihood Ratio: {lr_stat}")
    print(f"p-value: {p_value}")
    print(f"Degrees of Freedom: {df}")
```

AR(2) and ARIMA(1,0,0) comparison

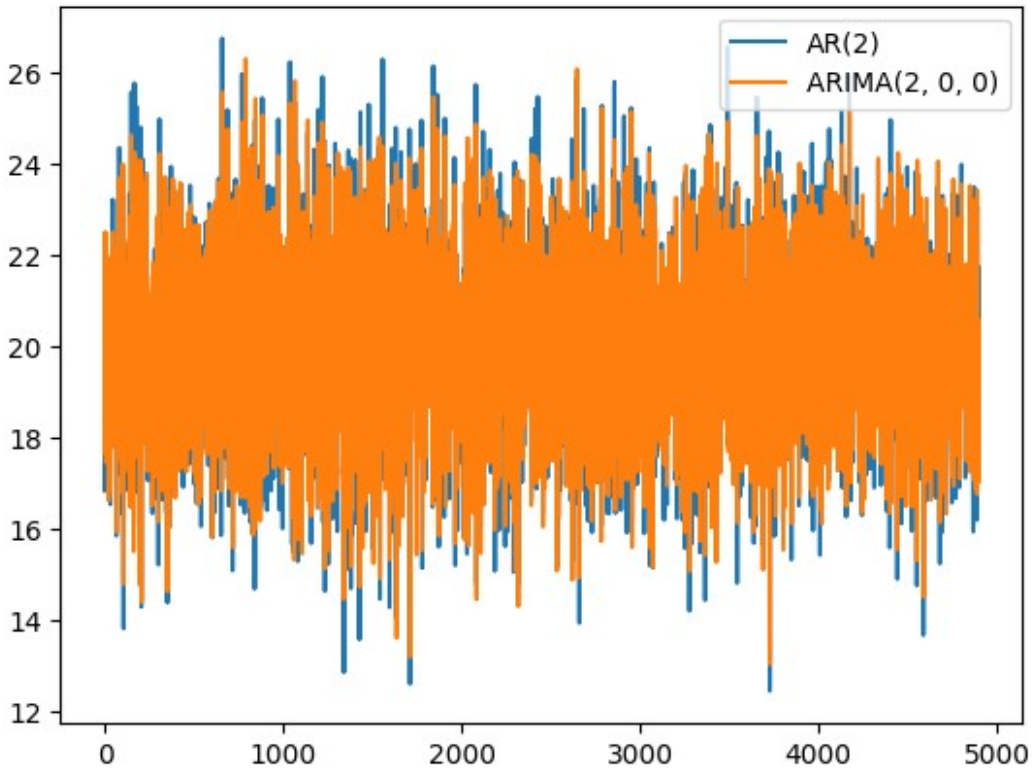
```
arima_model_1, arima_1_model_AIC, arima_1_model_BIC =
arima_fit_and_present(ar_model_2,1)
```




```
for Arima model 1 fit  AIC is 16937.78324, BIC is 16957.27421
```

AR(2) and ARIMA(2,0,0) comparison

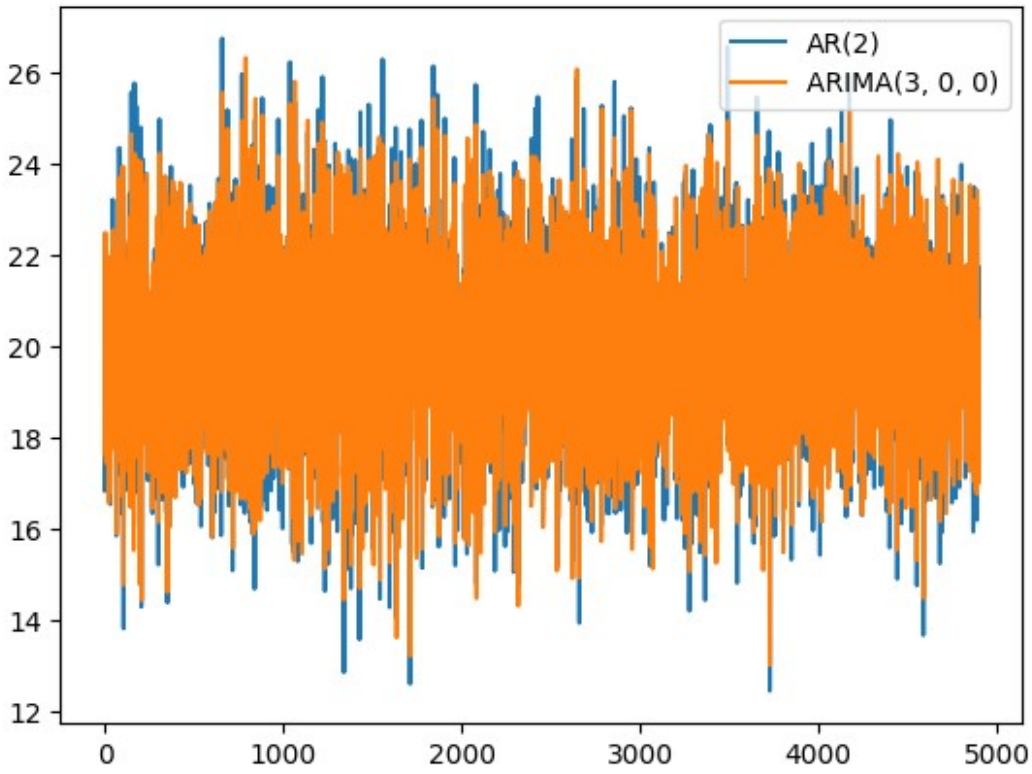
```
arima_model_2, arima_2_model_AIC, arima_2_model_BIC =
arima_fit_and_present(ar_model_2,2)
```




```
for Arima model 2 fit  AIC is 13750.51433, BIC is 13776.5023
```

AR(2) and ARIMA(3,0,0) comparison

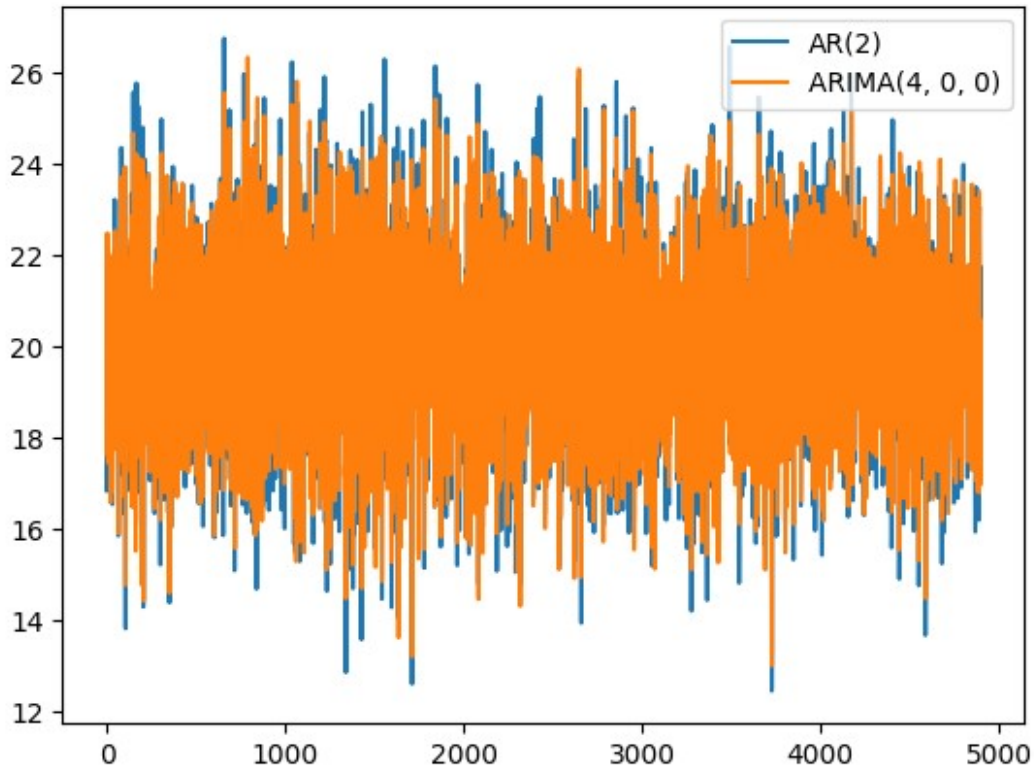
```
arima_model_3, arima_3_model_AIC, arima_3_model_BIC =
arima_fit_and_present(ar_model_2,3)
```




```
for Arima model 3 fit  AIC is 13748.99861, BIC is 13781.48357
```

AR(2) and ARIMA(4,0,0) comparison

```
arima_model_4, arima_4_model_AIC, arima_4_model_BIC =
arima_fit_and_present(ar_model_2,4)
```




```
for Arima model 4 fit  AIC is 13749.06464, BIC is 13788.04658
```

LLRT comparisons between ARIMA models

```
print("Arima model 1 vs 2")
perform_llrt(arima_model_1, arima_model_2)
print("")

print("Arima model 2 vs 3")
perform_llrt(arima_model_2, arima_model_3)
print("")

print("Arima model 3 vs 4")
perform_llrt(arima_model_3, arima_model_4)
print("")
```

```
Arima model 1 vs 2
Likelihood Ratio: 3189.268902162901
p-value: 0.0
Degrees of Freedom: 1

Arima model 2 vs 3
Likelihood Ratio: 3.515720616627732
p-value: 0.060789215845300094
Degrees of Freedom: 1
```

```
Arima model 3 vs 4
Likelihood Ratio: 1.9339728878858296
p-value: 0.16432444560833348
Degrees of Freedom: 1
```

ARIMA 1 vs 2 LLRT

For "Arima model 1 vs 2", the likelihood ratio is large and the p-value is 0, indicating that the data is much more likely under the ARIMA(2,0,0) model than the ARIMA(1,0,0) model.

ARIMA 2 vs 3 LLRT For "Arima model 2 vs 3", the likelihood ratio is small and the p-value is greater than 0.05, indicating that the data is not significantly more likely under the ARIMA(3,0,0) model than the ARIMA(2,0,0) model.

ARIMA 3 vs 4 LLRT

For "Arima model 3 vs 4", similar to the second case, the likelihood ratio is small and the p-value is greater than 0.05, indicating that the data is not significantly more likely under the ARIMA(4,0,0) model than the ARIMA(3,0,0) model.

Summary

In summary, based on these tests, the ARIMA(2,0,0) model seems to be the best fit.

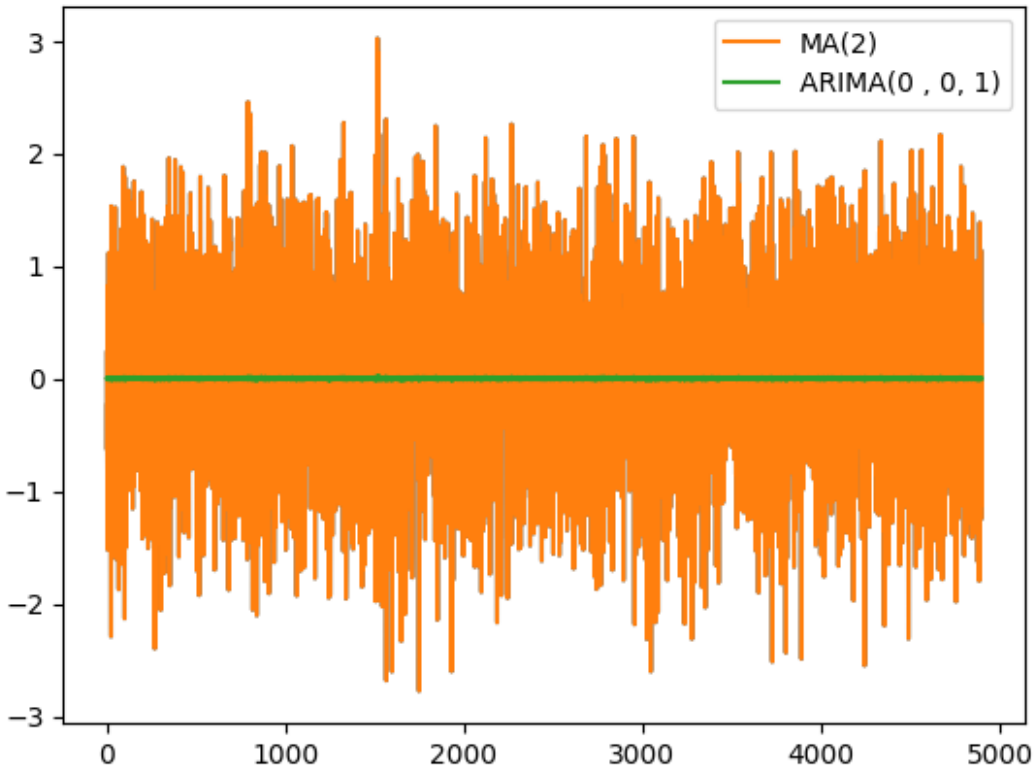
Conclusions for AR(2)

In case of AR(2) the best fittin ARIMA was ARIMA(2,0,0) which makes sense because it is basically implementation of AR(2) model.

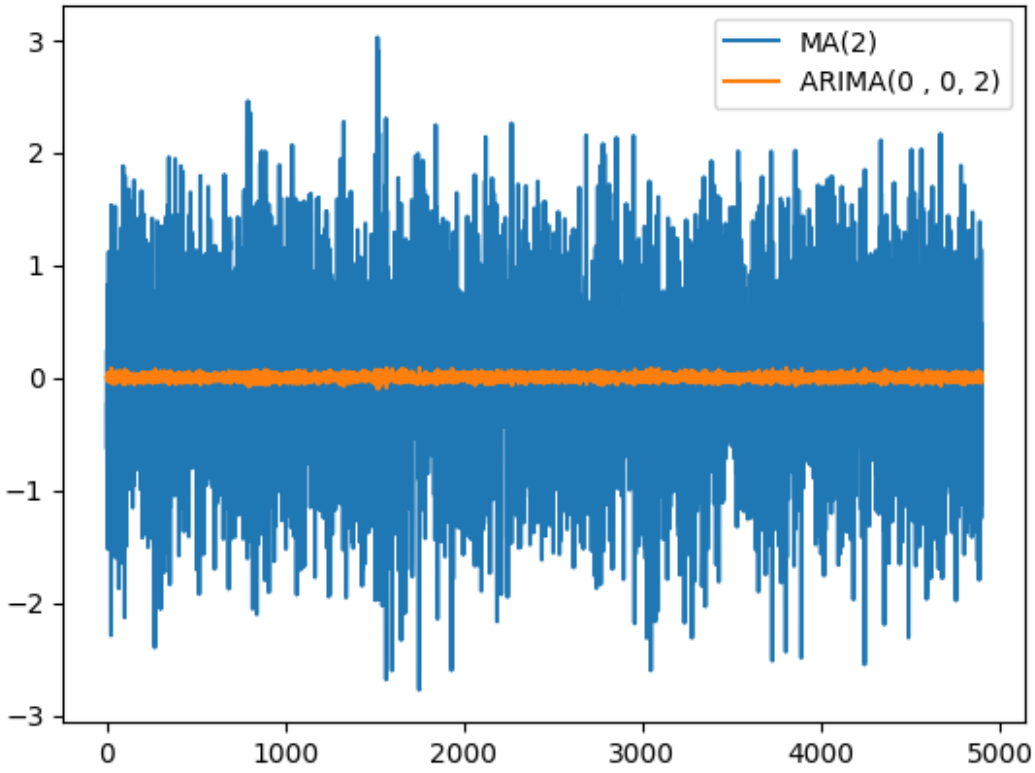
MA(2) fitting

```
def generate_ma_model(c, theta_values, epsilon_values, burnin):
    ma_values = []

    for t in range(len(epsilon_values)):
        sum_theta_epsilon = 0

        for q in range(len(theta_values)):
            if t - q - 1 >= 0:
                sum_theta_epsilon += theta_values[q] *
epsilon_values[t-q]


        ma_value = c + epsilon_values[t] + sum_theta_epsilon

        if t >= burnin:
            ma_values.append(ma_value)

    return ma_values

from statsmodels.tsa.arima.model import ARIMA
```

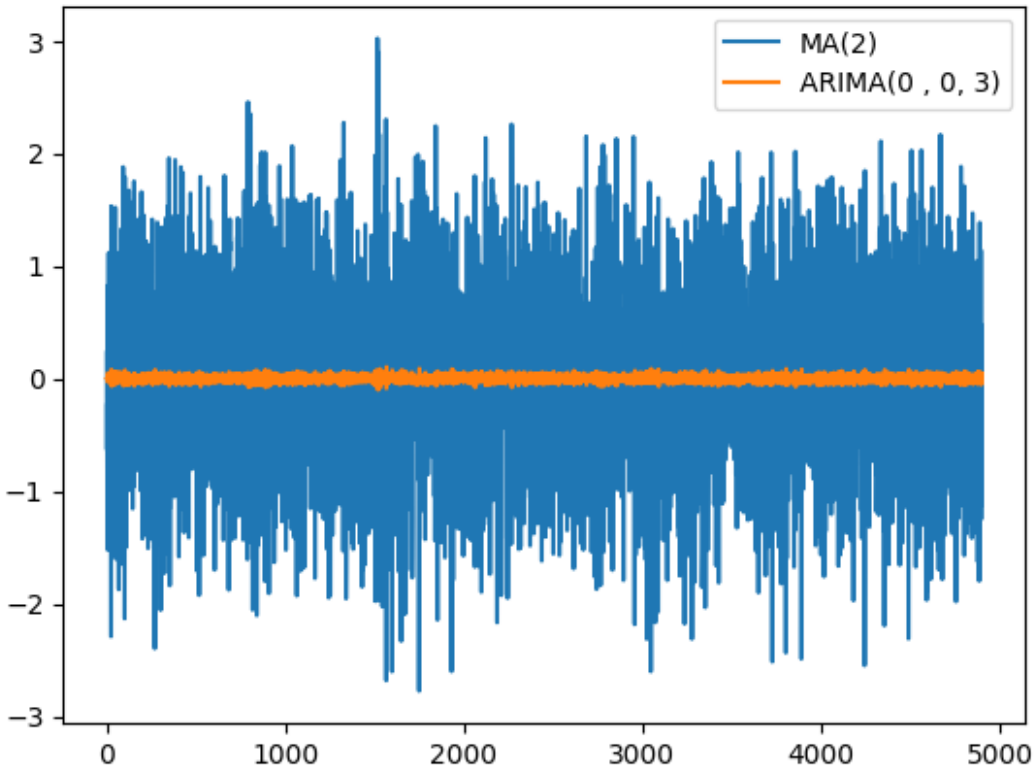
```
def arima_fit_and_present_ma(ma_model, arima_num):

    arima_model = ARIMA(ma_model, order=(0, 0, arima_num))
    model_fit = arima_model.fit()

    plt.plot(ma_model, label='MA(2)')
    plt.plot(model_fit.fittedvalues, label=f'ARIMA(0 , 0,
{arima_num})')
    plt.legend()
    plt.show()

    arima_model_AIC = round(model_fit.aic,5)
    arima_model_BIC = round(model_fit.bic,5)
    print(f'for Arima model {arima_num} fit  AIC is {arima_model_AIC},
BIC is {arima_model_BIC}')

    return model_fit, arima_model_AIC, arima_model_BIC

# Generate MA(2) model
ma_model_2 = generate_ma_model(0,[-1, 0.8], random_values_5k, 100)
plt.plot(ma_model_2)

# Fit ARIMA models to the MA(2) model and perform LLRT
arima_model_1, _, _ = arima_fit_and_present_ma(ma_model_2, 1)
arima_model_2, _, _ = arima_fit_and_present_ma(ma_model_2, 2)
arima_model_3, _, _ = arima_fit_and_present_ma(ma_model_2, 3)
arima_model_4, _, _ = arima_fit_and_present_ma(ma_model_2, 4)

print("Arima model 1 vs 2")
perform_llrt(arima_model_1, arima_model_2)
print("")

print("Arima model 2 vs 3")
perform_llrt(arima_model_2, arima_model_3)
print("")

print("Arima model 3 vs 4")
perform_llrt(arima_model_3, arima_model_4)
print("")
```



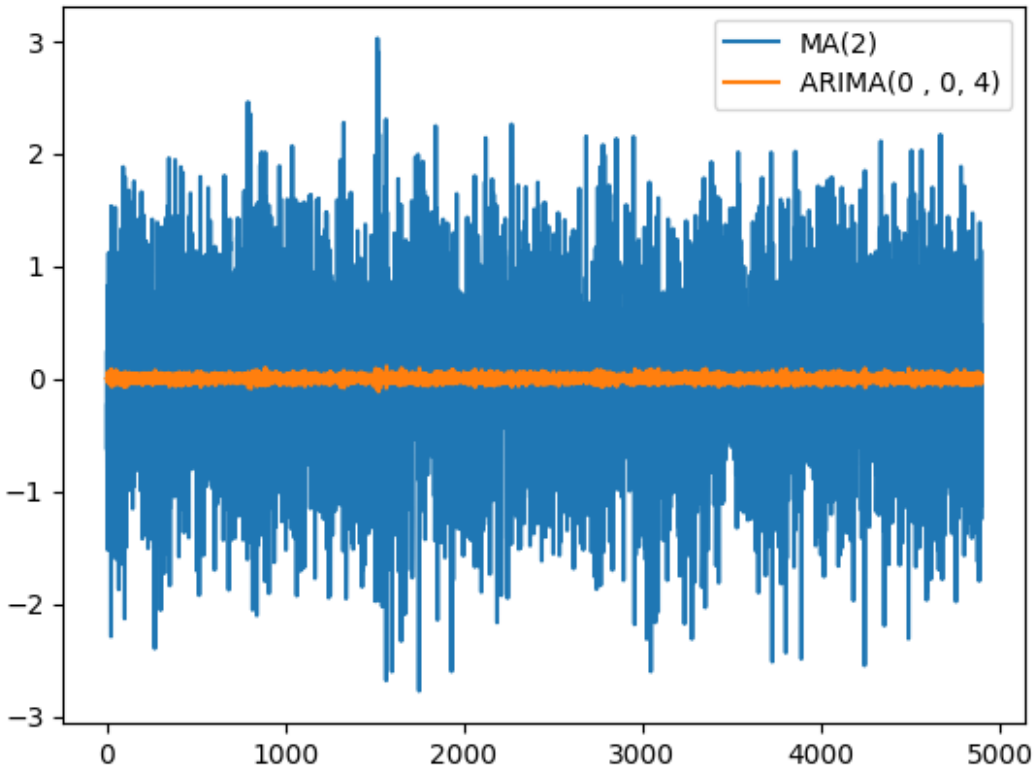

```
for Arima model 1 fit  AIC is 11558.13791, BIC is 11577.62888
```



```
for Arima model 2 fit  AIC is 11555.33911, BIC is 11581.32707
```




```
for Arima model 3 fit  AIC is 11557.09766, BIC is 11589.58261
```




```
for Arima model 4 fit  AIC is 11558.31762, BIC is 11597.29956
Arima model 1 vs 2
Likelihood Ratio: 4.798803136724018
p-value: 0.02847951500244803
Degrees of Freedom: 1

Arima model 2 vs 3
Likelihood Ratio: 0.24145177063110168
p-value: 0.6231595302710768
Degrees of Freedom: 1

Arima model 3 vs 4
Likelihood Ratio: 0.7800426892099495
p-value: 0.37712808422845434
Degrees of Freedom: 1
```

ARIMA 1 vs 2 LLRT

For "Arima model 1 vs 2", the likelihood ratio is small and the p-value is greater than 0.05, indicating that the data is not significantly more likely under the ARIMA(0, 0, 2) model than the ARIMA(0, 0, 1) model.

ARIMA 2 vs 3 LLRT

For "Arima model 2 vs 3", the likelihood ratio is small and the p-value is greater than 0.05, indicating that the data is not significantly more likely under the ARIMA(0, 0, 3) model than the ARIMA(0, 0, 2) model.

ARIMA 3 vs 4 LLRT

For "Arima model 3 vs 4", the likelihood ratio is small and the p-value is greater than 0.05, indicating that the data is not significantly more likely under the ARIMA(0, 0, 4) model than the ARIMA(0, 0, 3) model.

Summary

In summary, based on these tests, none of the ARIMA models provide a significantly better fit than the others for the MA(2) model. This suggests that the MA(2) model may not be well-represented by an ARIMA model of the orders tested.

Conclusions

In conclusion, I recieved expected results from AR(2) and ARIMA(2,0,0) fitting but something unexpected happend where ARIMA(0,0,2) should be perfect representation of MA(2).