Hidden Markov Models

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In this notebook, we will apply Hidden Markov model to simulated data to test if it can predict market regimes.

At this stage, we will only simulate two-regime and assuming the market returns are normally distributed. These are the parameters used to predict a bull and bear market returns

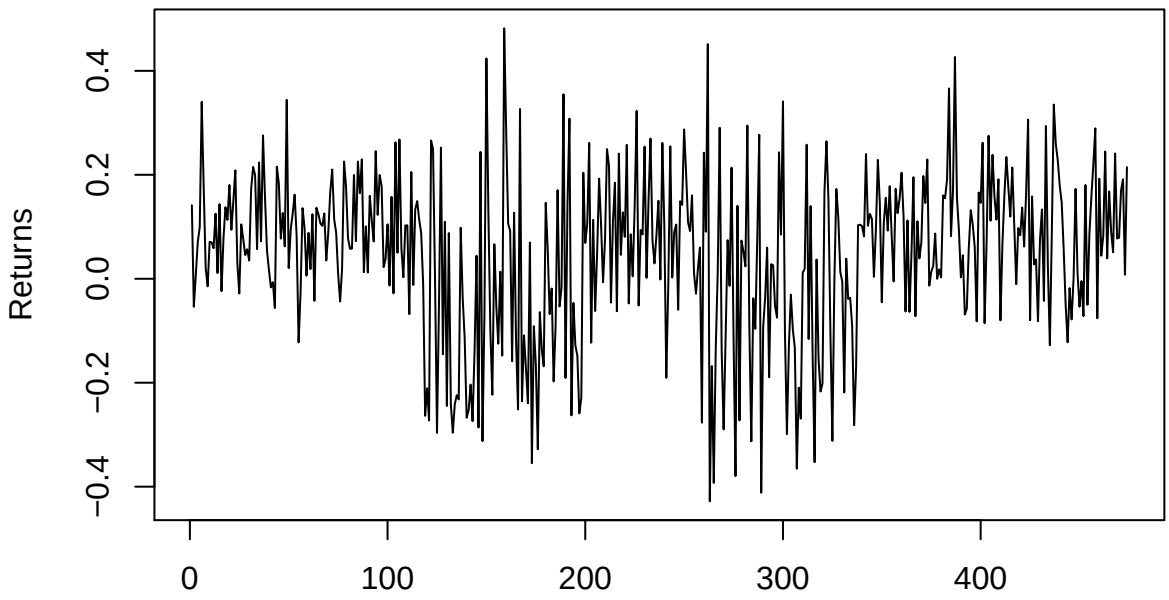
```
Nk_lower <- 50
Nk_upper <- 150
bull_mean <- 0.1
bull_var <- 0.1
bear_mean <- -0.05
bear_var <- 0.2
days <- replicate(5, sample(Nk_lower:Nk_upper, 1))
```

Below is returns for kth period are randomly drawn

```
market_bull_1 <- rnorm( days[1], bull_mean, bull_var)
market_bear_2 <- rnorm( days[2], bear_mean, bear_var)
market_bull_3 <- rnorm( days[3], bull_mean, bull_var)
market_bear_4 <- rnorm( days[4], bear_mean, bear_var)
market_bull_5 <- rnorm( days[5], bull_mean, bull_var)
```

Encoding 1 for bullish and 2 for bearish

```
true_regimes <- c( rep(1, days[1]), rep(2,days[2]), rep(1,days[3]), rep(2,days[4]), rep(1, days[5]))
returns <- c( market_bull_1, market_bear_2, market_bull_3, market_bear_4, market_bull_5)
plot(returns, type='l', xlab = '', ylab = 'Returns')
```

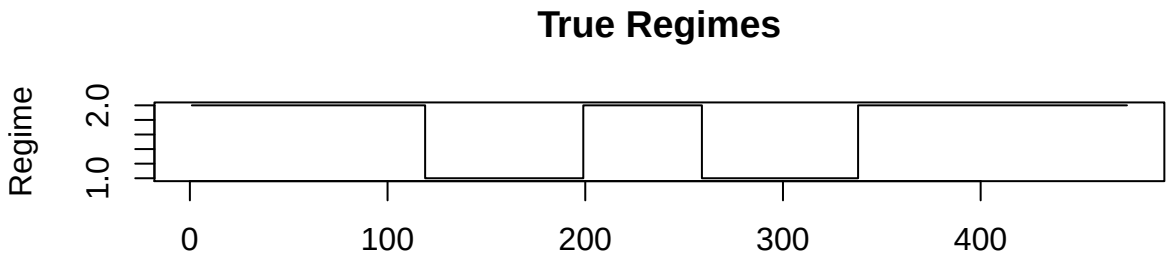


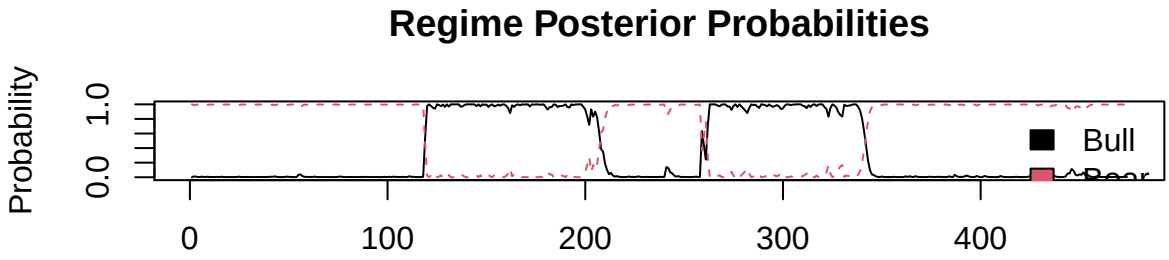

```
hmm <- depmix(returns ~ 1, family = gaussian(), nstates=2, data= data.frame(returns=returns))
hmmfit <- fit(hmm,verbose = FALSE)
```

```
## converged at iteration 24 with logLik: 289.6389
```

Outputting both the true regimes and the posterior probabilities of the regimes

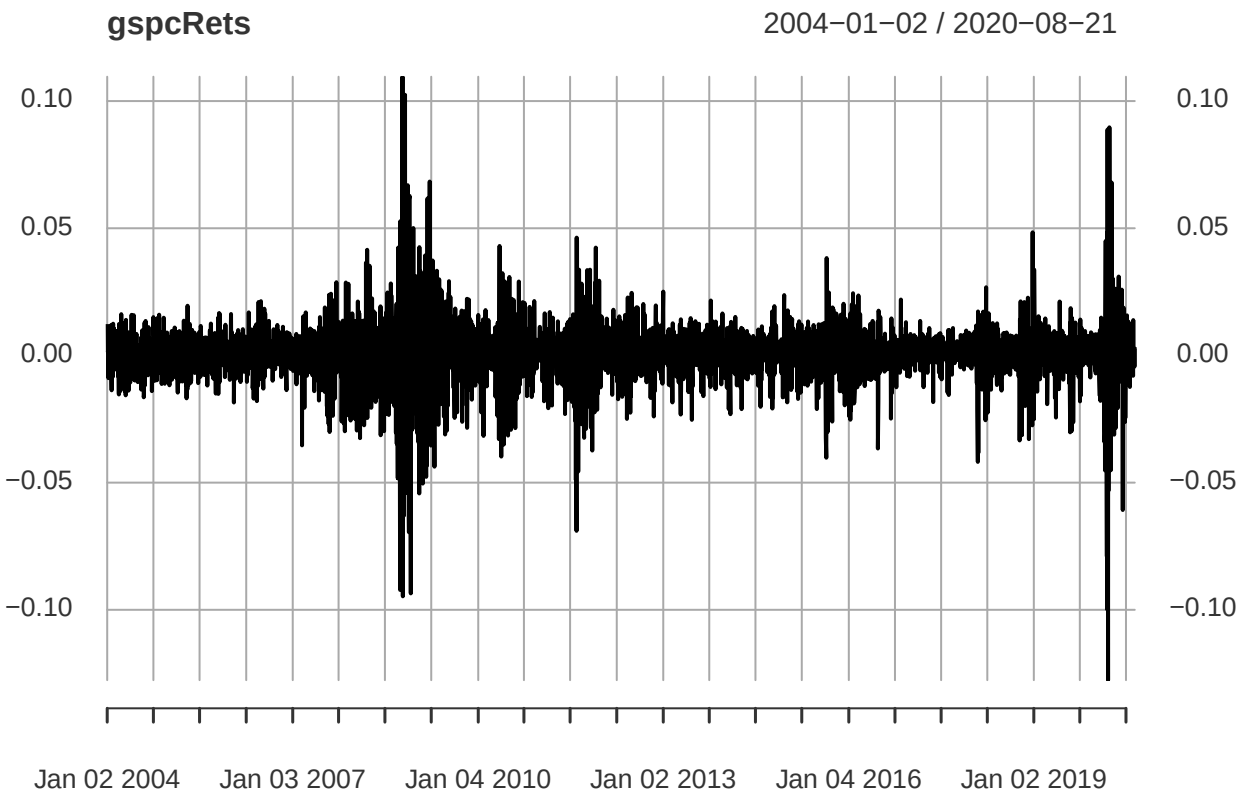
```
post_probs <- posterior(hmmfit)
layout(1:2)
plot(post_probs$state, type='s', main='True Regimes', xlab="",ylab = 'Regime')
matplot(post_probs[,-1], type="l", main='Regime Posterior Probabilities', ylab='Probability')
legend(x='topright', c('Bull','Bear'), fill=1:2, bty='n')
```





Instead of using simulated data we will now run it on sp500 returns

```
layout(1)
plot(gspcRets)
```



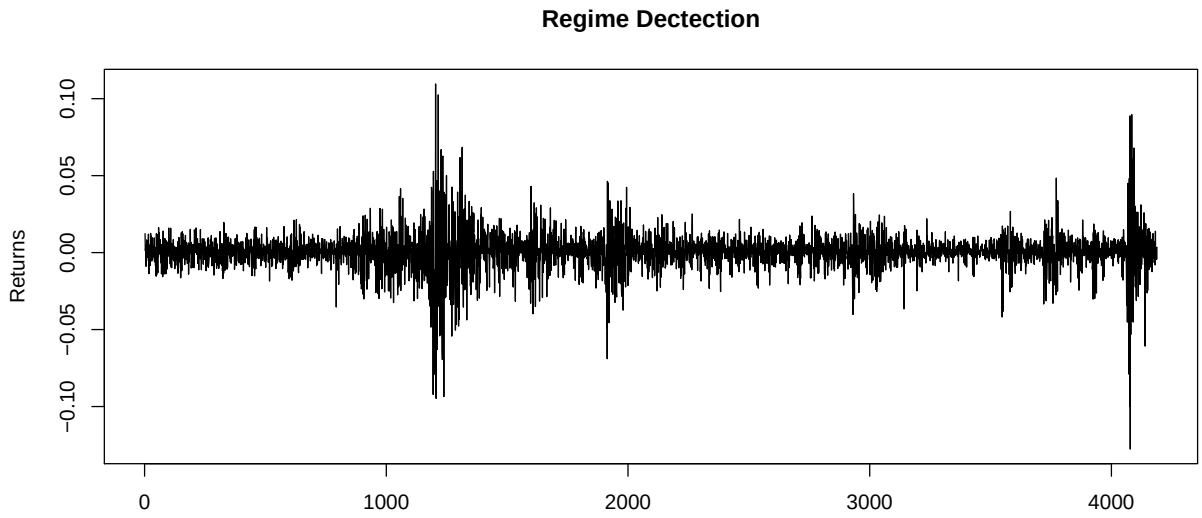
We will now proceed to fit the two state HMM with EM algorithm

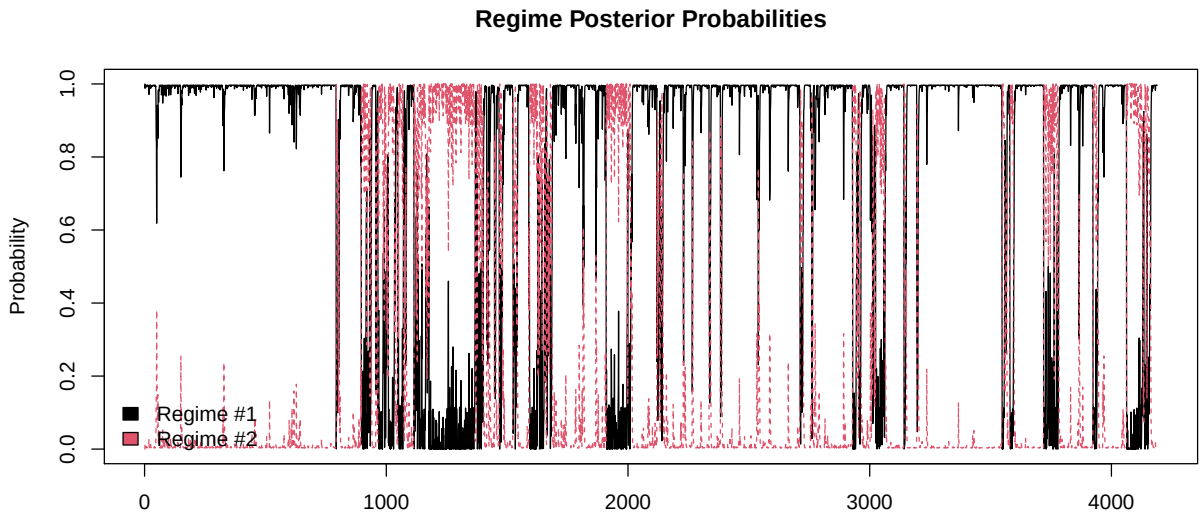
```
hmm <- depmix(returns ~ 1, family=gaussian(), nstates=2, data=data.frame(returns=returns))
hmmfit <- fit(hmm, verbose=FALSE)
```

```
## converged at iteration 35 with logLik: 13676.17
```

```
post_probs = posterior(hmmfit)

# Plotting the return stream and the posterior probabilities of the separate regimes
layout(1:2)
plot(returns, type='l', main='Regime Dectection', xlab='', ylab='Returns')
matplot(post_probs[,-1], type='l', main='Regime Posterior Probabilities', ylab='Probability')
legend(x='bottomleft', c('Regime #1','Regime #2'), fill=1:2, bty='n')
```






```
rownames(post_probs) <- index(GSPC)
```

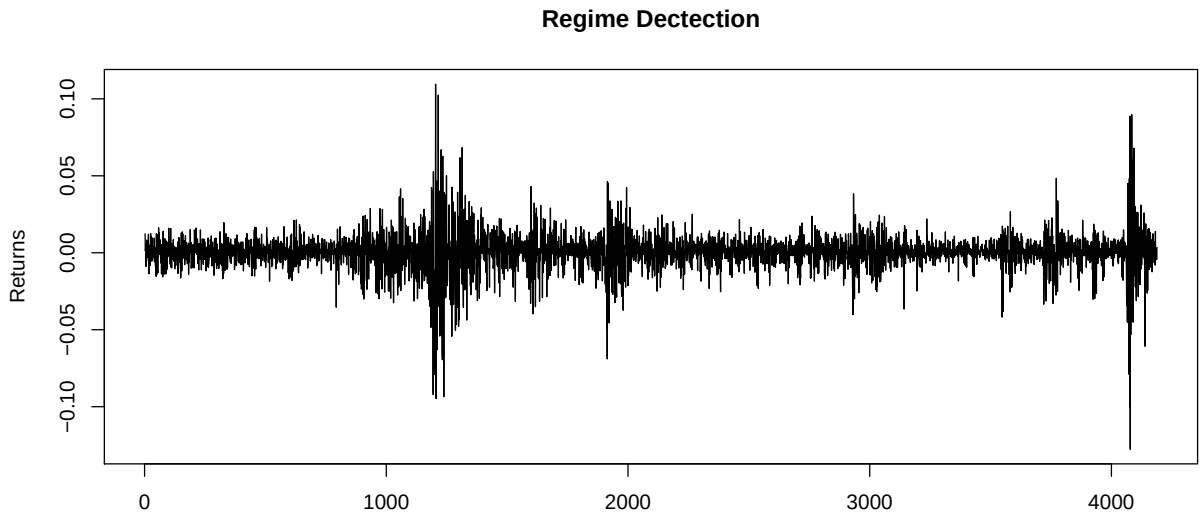
We will now switch to a 3 state regime

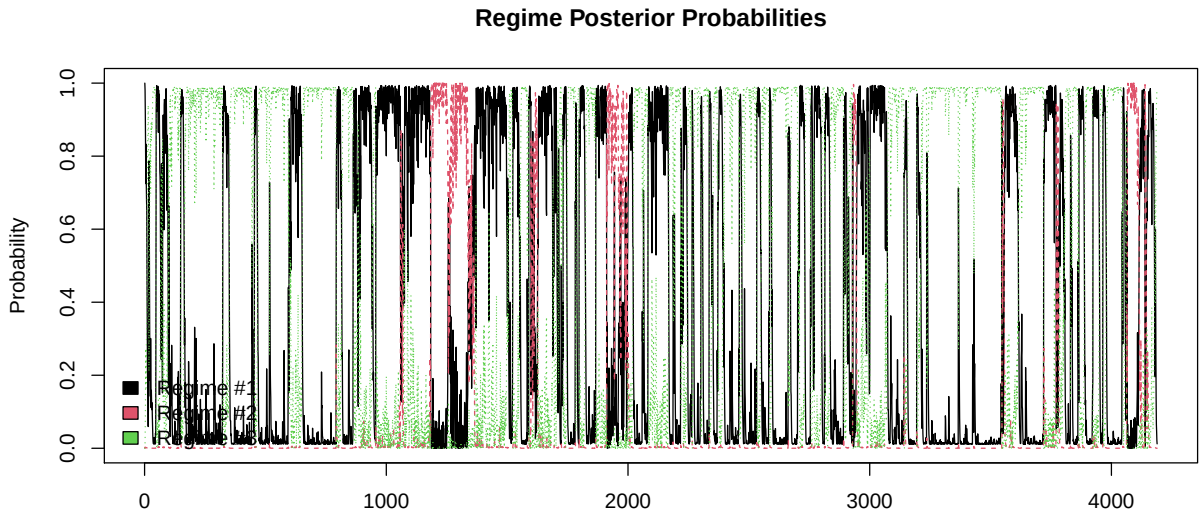
```
hmm <- depmix(returns ~ 1, family=gaussian(), nstates=3, data=data.frame(returns=returns))
hmmfit <- fit(hmm, verbose=FALSE)
```

```
## converged at iteration 112 with logLik: 13892.61
```

```
post_probs = posterior(hmmfit)

# Plotting the return stream and the posterior probabilities of the separate regimes
layout(1:2)
plot(returns, type='l', main='Regime Dectection', xlab='', ylab='Returns')
matplot(post_probs[,-1], type='l', main='Regime Posterior Probabilities', ylab='Probability')
legend(x='bottomleft', c('Regime #1','Regime #2','Regime #3'), fill=1:3, bty='n')
```






```
rownames(post_probs) <- index(GSPC)
```