Machine Learning with NNS

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There was a recent image that was posted[1], and NNS' seamless integration of the identified tasks (clustering, regression, and classification) in machine learning was apparent. **It is a regression based on clusters!**.

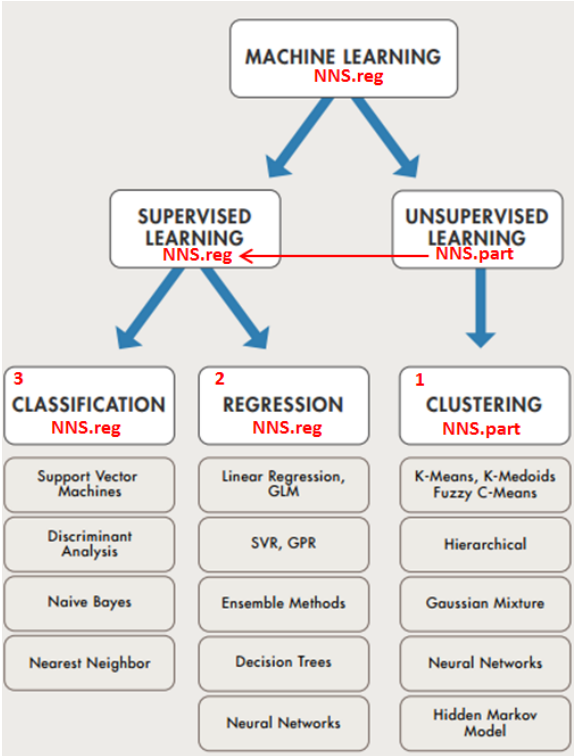

Figure 1: Machine Learning Diagram

[1] http://www.datasciencecentral.com/profiles/blogs/machine-learning-summarized-in-one-picture

1 Clustering

Reference:
Clustering and Curve Fitting by Line Segments
https://ssrn.com/abstract=2861339

The first step of NNS regression (`NNS.reg`) is to iteratively partition the data into partial moment quadrants and assign a sequential quadrant number to each observation. **It is both a partitional and hierarchical clustering.**
Below is a visualization of the unsupervised NNS partitioning (`NNS.part`) and the resulting clusters (red points):

```
require(devtools)
install_github('OVVO-Financial/NNS',ref = "NNS-Beta-Version")
require(NNS)
x=seq(0,4*pi,pi/1000);y=sin(x)
par(mfrow=c(2,3))
for(i in 1:6){
  NNS.part(x,y,order=i,min.obs = 1,Voronoi = T)
}
```

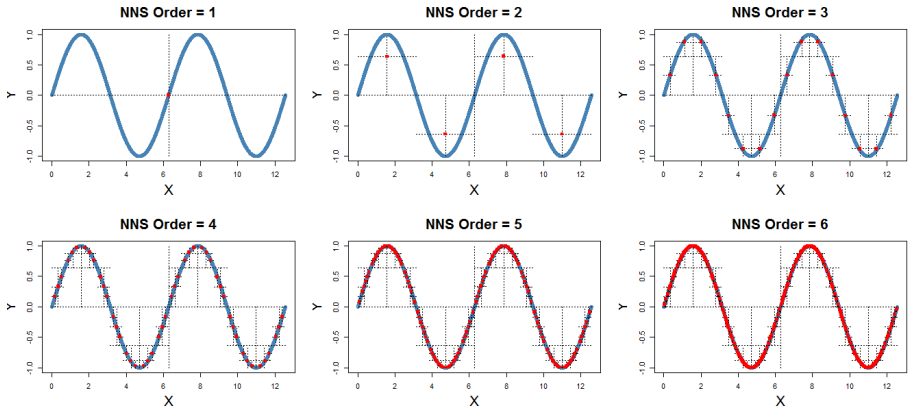

Figure 2: NNS partition and clustering

2 Regression

Reference:
Nonparametric Regression Using Clusters
https://link.springer.com/article/10.1007/s10614-017-9713-5

`NNS.reg` uses the `NNS.part` clusters as the basis of a nonlinear nonparametric regression.

2.1 UNIVARIATE REGRESSION:

```
for(i in 1:6){
  NNS.reg(x,y,order=i,noise.reduction = 'off')
}
```

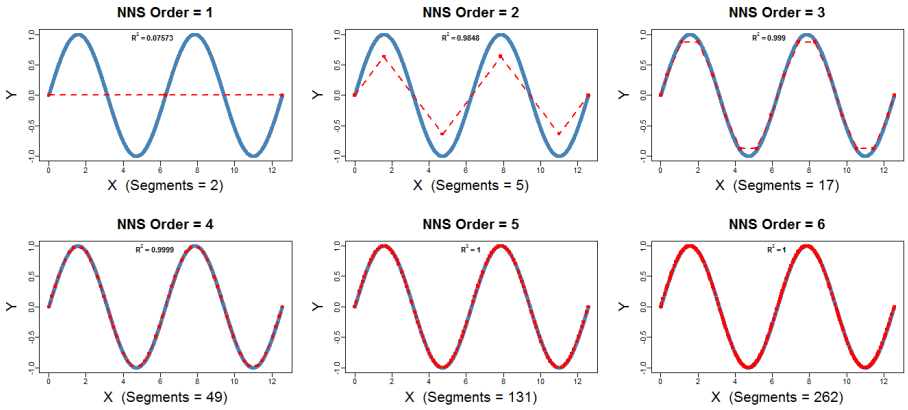

Figure 3: NNS regression sequence of orders in univariate example.

2.2 MULTIVARIATE REGRESSION:

NNS extends this partitioning and clustering to higher dimensions for a complete multivariate analysis.

```
f <- function(x, y) x^3+3*y-y^3-3*x
x <- seq(-5, 5, 0.1);y <- seq(-5, 5, 0.1)
z <- expand.grid(x,y)
g <- f(z[,1],z[,2])
for(i in 1:6){
NNS.reg(z,g,plot.regions = T,order=i)}
```

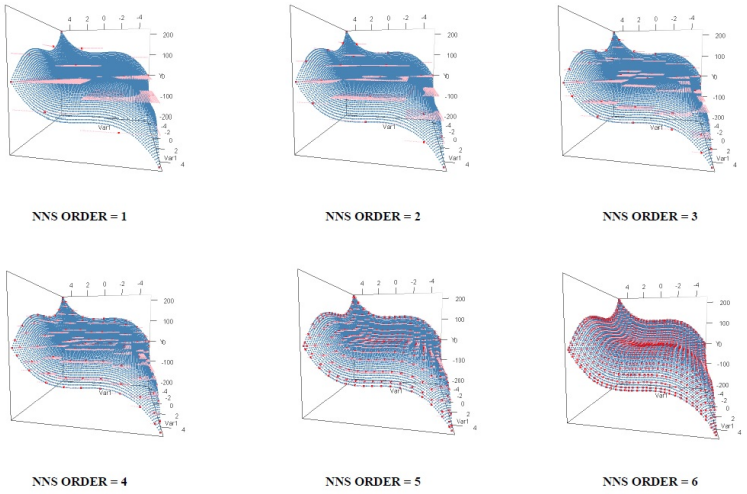

Figure 4: NNS multivariate regression progression of orders.

Multivariate $\hat{Y}$ vs. Y Plot:

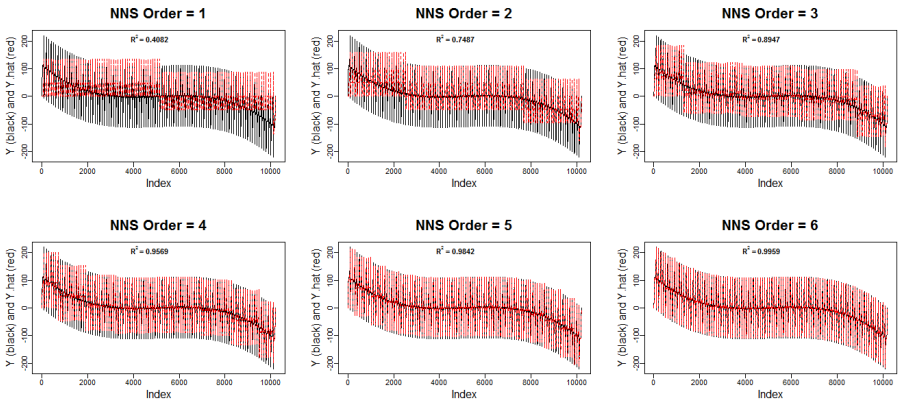

Figure 5: NNS multivariate regression $\hat{Y}$ vs. Y plot.

3 Classification

Reference:
Classification Using NNS Clustering Analysis
https://ssrn.com/abstract=2864711

`NNS.reg` is also applicable to classification methods and for smaller dimensions will report the same output as a k-nearest neighbor algorithm (KNN) when both are set to $k = 1$ under specific NNS settings (limit condition whereby every observation is its own cluster). NNS does not have the same restrictions as KNN, such as using an odd numbered k to avoid ties. When dimensions are increased substantially, NNS and KNN estimates diverge showing KNN is more sensitive to the curse of dimensionality than NNS.

The above reference demonstrates several classification tasks from Iris, UCI Wine dataset, an XOR classification, the Cassini dataset and a text classification example. NNS multivariate regression excels at all instances. Preliminary examination of the MNIST dataset using NNS and KNN shows a 75% reduction in error rate when using NNS instead of KNN. Available here: https://goo.gl/Vn0fBS

4 Time-Series Forecasting

Reference:
Forecasting Using NNS
https://ssrn.com/abstract=3382300

`NNS.reg` has also been integrated into a time-series forecasting routine. Regressions are performed on seasonal components, without the need for stationarity or ACF / PACF analysis.

For an example of NNS against KERAS LSTM, or Facebook's Prophet see the following directory: https://github.com/OVVO-Financial/NNS/tree/NNS-Beta-Version/examples

```
x <- seq(0,30,.01); y <- sin(x)
NNS.ARMA(y, h=1000, negative.values = TRUE, method = 'lin')
```

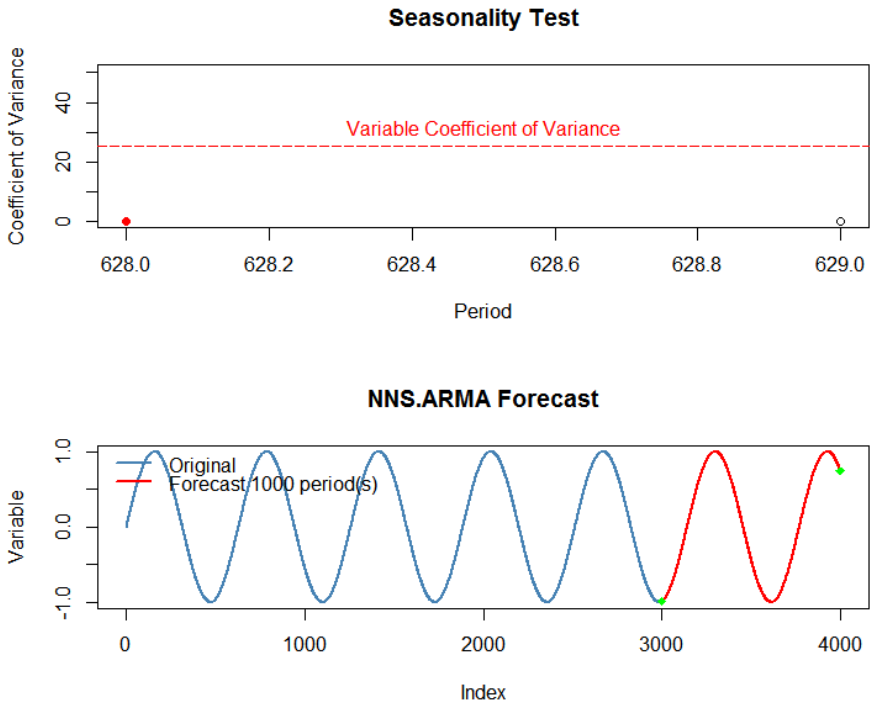

Figure 6: NNS seasonal periods and resulting forecast.

More NNS:

To learn more about NNS statistics and their theoretical foundations, see *"Nonlinear Nonparametric Statistics: Using Partial Moments"* available on Amazon: http://a.co/5bpHvUg
Check back to see more NNS examples posted on GitHub: https://github.com/OVVO-Financial/NNS/tree/NNS-Beta-Version/examples