```r
#===============================================================================
#               Using R: Truck Classification (Bridge Sensor Data)
#===============================================================================
#This is based on a real research project and real-world data; ...
Sensor.Data <- read.csv(file="bridgeSensor.csv", head=TRUE, sep=",")
#-------------------------------------------------------------------------------
#(a) Given that the goal of the research project was to classify ...
Sensor11 <- Sensor.Data[1:801,c(1,2)]
Sensor12 <- Sensor.Data[802:length(Sensor.Data$Time),c(1,2)]
Sensor21 <- Sensor.Data[1:801,c(1,3)]
Sensor22 <- Sensor.Data[802:length(Sensor.Data$Time),c(1,3)]
S11 <- fft(Sensor11$Sensor1)
S12 <- fft(Sensor12$Sensor1)
S21 <- fft(Sensor21$Sensor2)
S22 <- fft(Sensor22$Sensor2)
par(mfrow=c(2,2))
PS11  <- cbind(0:(length(S11)-1), Mod(S11))
plot(PS11, t="h", lwd=2, main="Sensor=1 / Truck=1", xlab="Frequency (Hz)",
ylab="Strength",
     xlim=c(0,length(S11)/2), ylim=c(0,max(Mod(PS11[,2]))))
PS12  <- cbind(0:(length(S12)-1), Mod(S12))
plot(PS12, t="h", lwd=2, main="Sensor=1 / Truck=2", xlab="Frequency (Hz)",
ylab="Strength",
     xlim=c(0,length(S12)/2), ylim=c(0,max(Mod(PS12[,2]))))
PS21  <- cbind(0:(length(S21)-1), Mod(S21))
plot(PS21, t="h", lwd=2, main="Sensor=2 / Truck=1", xlab="Frequency (Hz)",
ylab="Strength",
     xlim=c(0,length(S21)/2), ylim=c(0,max(Mod(PS21[,2]))))
PS22  <- cbind(0:(length(S22)-1), Mod(S22))
plot(PS22, t="h", lwd=2, main="Sensor=2 / Truck=2", xlab="Frequency (Hz)",
ylab="Strength",
     xlim=c(0,length(S22)/2), ylim=c(0,max(Mod(PS22[,2]))))
par(mfrow=c(1,1))
#Based on the exploration, we can have some candidate features.
#1. Using the maximum absolute value of the accelerogram.
#It means if the truck has more wight it produces high acceleration too.
#2. Using the maximum strength value of the data after Fourier transformation.
#The same as above. The more weight the truck has the more strength can be seen in the
Fourier graph.
#3. Using the value of frequency corresponding to peak value.
#Each structure have various fundamental modes and frequencies. Also, each truck has a
main frequency too.
#So the truck would motivate the frequency of the structure which is near its
frequency. So it causes different
#shifting in the furior graph.
#-------------------------------------------------------------------------------
#(b) Use the available data to construct the features as possible from part ...

#1.
#Sensor 1 / Truck 1
max(abs(Sensor11$Sensor1))
## [1] 0.09403992
#Sensor 1 / Truck 2
max(abs(Sensor12$Sensor1))
## [1] 0.1303779
#Sensor 2 / Truck 1
max(abs(Sensor21$Sensor2))
## [1] 0.07770321
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```r
#Sensor 2 / Truck 2
max(abs(Sensor22$Sensor2))
## [1] 0.0877345
#from the maximum absolute value above it can be understand that the Truck 1 has less
weight than Truck 2

#2.
#Sensor 1 / Truck 1
max(PS11[,2])
## [1] 3.569323
#Sensor 1 / Truck 2
max(PS12[,2])
## [1] 2.945742
#Sensor 2 / Truck 1
max(PS21[,2])
## [1] 2.558214
#Sensor 2 / Truck 2
max(PS22[,2])
## [1] 2.280355
#Using the maximum value of the furior the same result can be drawn which Truck 1 is
heavier than Trcuk 2.

#3.
#Sensor 1 / Truck 1
which.max(PS11[1:(length(PS11[,2])/2),2])
## [1] 114
#Sensor 1 / Truck 2
which.max(PS12[1:(length(PS12[,2])/2),2])
## [1] 135
#Sensor 2 / Truck 1
which.max(PS21[1:(length(PS21[,2])/2),2])
## [1] 114
#Sensor 2 / Truck 2
which.max(PS22[1:(length(PS22[,2])/2),2])
## [1] 154
#As can be seen each truck motivate different frequencies of the structure.
#-----------------------------------------------------------------------------------------
#(c) Describe any difficulties that you encounter in engineering ...

#There is a shortage of data. We have only one sample and it is difficult to find any
pattern with only one observation for each truck. It may be more heavy vehicles
passing the bridge at the same time, so it is going to mess up the data. From the
civil engineering point of view, the properties of the bridge should also be known.
#It could help distinguish between various vehicles. By knowing the natural frequency
of the bridge, it can be understood what the natural frequency of the vehicle is
(which frequency is motivated). Also, the location of the sensors is important to
correlate the result of two sensors.
```