# 3D Printing data

WEI, LIANG YU

## DATA

```
data <- read.csv("gauge.csv",header=T)
data <- data[1:180,1:11]
y1 <- data[,3] #Diameter
y2 <- data[,4] #Length
y3 <- data[,5] #Width
y4 <- data[,6] #Left
y5 <- data[,7] #Left-Center
y6 <- data[,8] #Center
y7 <- data[,9] #Right
y8 <- data[,10] #Right-Center
y9 <- data[,11] #Height

P <- factor(data[,1]) #產品序號
p = max(as.numeric(P)) #產品總數量 = 最大產品序號 = 20

O <- factor(data[,2]) #檢測人員編號
o = max(as.numeric(O)) #檢測人員數 = 最大檢測人員編號 = 3

# n = 每人測量次數 = 1號產品被檢測次數 / 檢測人員數 = 3
n = length(which(P == '1')) / o

cat("產品數量 = ", p, "\n")
```

```
## 產品數量 =  20
```

```
cat("檢測人員數 = ", o, "\n")
```

```
## 檢測人員數 =  3
```

```
cat("每人測量次數 = ", n)
```

```
## 每人測量次數 =  3
```

# GRR amd P/T and SNR and DR function

```
calculate.size = function(x){
  rlt<-aov(x~P*O)
  summary(rlt)
  MSp <- summary(rlt)[[1]][1, 'Mean Sq']
  MSo <- summary(rlt)[[1]][2, 'Mean Sq']
  MSpo <- summary(rlt)[[1]][3, 'Mean Sq']
  MSe <- summary(rlt)[[1]][4, 'Mean Sq']

  #sigma-squared如果小於零，直接令成0
  if ( (MSp - MSpo)/(o*n)  <= 0) { sigp = 0 }
  else { sigp = (MSp - MSpo)/(o*n) }

  if ( (MSo - MSpo)/(p*n) <= 0) { sigo = 0 }
  else { sigo = (MSo - MSpo)/(p*n) }

  if ( (MSpo - MSe)/n <= 0) { sigpo = 0 }
  else { sigpo = (MSpo - MSe)/n }

  sigmse <- MSe

  #### sigma square gauge = sigma square reproducibility + sigma square repeatability ####
  sigrepro <- sigo + sigpo
  sigrepeat <- sigmse
  siggau <- sigrepro + sigrepeat

  #### P/T ratio = (k*sigma square Gauge) / (USL - LSL) ####
  USL_LSL <- 0.5
  k1 <- 5.15 #95%
  k2 <- 6 #99%

  P_T_k1 <- k1*sqrt(siggau)/USL_LSL
  P_T_k2 <- k2*sqrt(siggau)/USL_LSL

  #### SNR (signal-to-noise-ratio) = sqrt( (2*rho_p) / (1-rho_p) ) ####

  # sigma square total = sigma square P + sigma square Gauge
  sigmatotal <- sigp + siggau

  # rho P = sigma square P / sigma square total = 1 - rho M
  rhop <- sigp / sigmatotal

  # rho M = sigma square Gauge / sigma square total
  rhom <- siggau / sigmatotal

  SNR <- sqrt(2*rhop/(1-rhop))

  #### Discrimination ratio (DR) ####
  DR <- (1+rhop)/(1-rhop)

  return(list(sigrepro = sigrepro, sigrepeat = sigrepeat, siggau = siggau, sigmatotal = sigma
total,
              P_T_k1 = P_T_k1, P_T_k2 = P_T_k2, rhop = rhop, rhom = rhom, SNR = SNR, DR = D
```

```
R))
}
```

## Result

```
result <- matrix(0,nrow = 9,ncol = 10)

for (i in 1:10)
{
  result[1,i]<-calculate.size(y1)[[i]]
  result[2,i]<-calculate.size(y2)[[i]]
  result[3,i]<-calculate.size(y3)[[i]]
  result[4,i]<-calculate.size(y4)[[i]]
  result[5,i]<-calculate.size(y5)[[i]]
  result[6,i]<-calculate.size(y6)[[i]]
  result[7,i]<-calculate.size(y7)[[i]]
  result[8,i]<-calculate.size(y8)[[i]]
  result[9,i]<-calculate.size(y9)[[i]]
}

result <- as.data.frame(round(result,4))
colnames(result) <- c("sigma-squared reproducibility","sigma-squared repeatability","sigma-sq
uared gauge","sigma-squared total","P/T ratio (k=5.15)","P/T ratio (k=6)","rhop","rhom","SN
R","DR")
rownames(result) <- c("diameter","length","width","left","left-center","center","right","righ
t-center","height")
result <- as.data.frame(result)
result
```

| | sigma-squared reproducibility <dbl> | sigma-squared repeatability <dbl> | sigma- |
|---|---|---|---|
| diameter | 0.0103 | 0.0130 | |
| length | 0.0163 | 0.0067 | |
| width | 0.0087 | 0.0063 | |
| left | 0.0013 | 0.0074 | |
| left-center | 0.0050 | 0.0119 | |
| center | 0.0072 | 0.0103 | |
| right | 0.0030 | 0.0129 | |
| right-center | 0.0026 | 0.0146 | |
| height | 0.0008 | 0.0059 | |

9 rows | 1-4 of 11 columns

## Conclusion

Measurement systems analysis(MSA) aims to test if the measurement process is capable. If the measurement process is capable, that needs to P/T Ratio <= 0.1, SNR >= 0.5, DR >= 4.

We guess the reason why all the indicators are not standardized is that the measurement data itself has a very large error, and the average allometric distance of each place to be measured is on the large side, so this gauge is not capable.