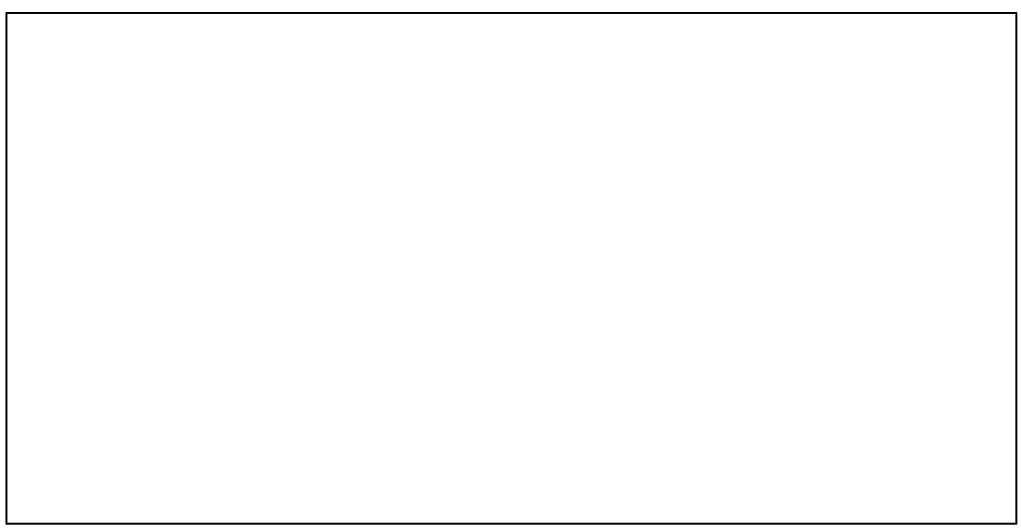
Q1

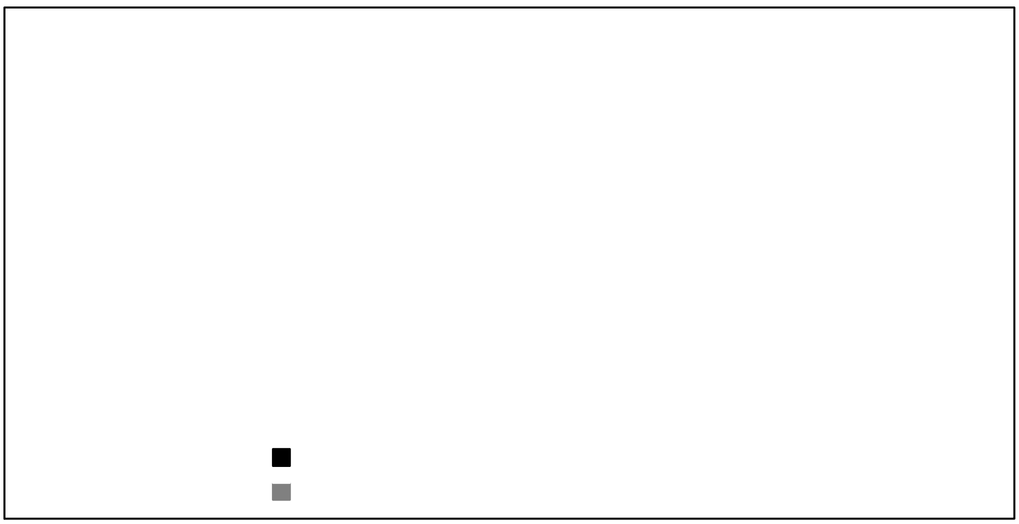
a)

```
initializeDigitPlot <- function() {
  plot(0, 0,
       xlab='', ylab='',
       xaxt='n', yaxt='n',
       xlim=c(0.5,28.5), ylim=c(0.5,28.5),
       col='white', asp=1)
}

initializeDigitPlot()
```



b)

```r
drawBox <- function(x,y,brightness){
  polygon(c(x-0.5,x-0.5,x+0.5,x+0.5), c(y-0.5,y+0.5,y+0.5,y-0.5),
          col=gray(1-brightness), border=gray(1-brightness))
}

initializeDigitPlot()
drawBox(1,1,0.5)
drawBox(1,2,0)
drawBox(1,3,1)
```

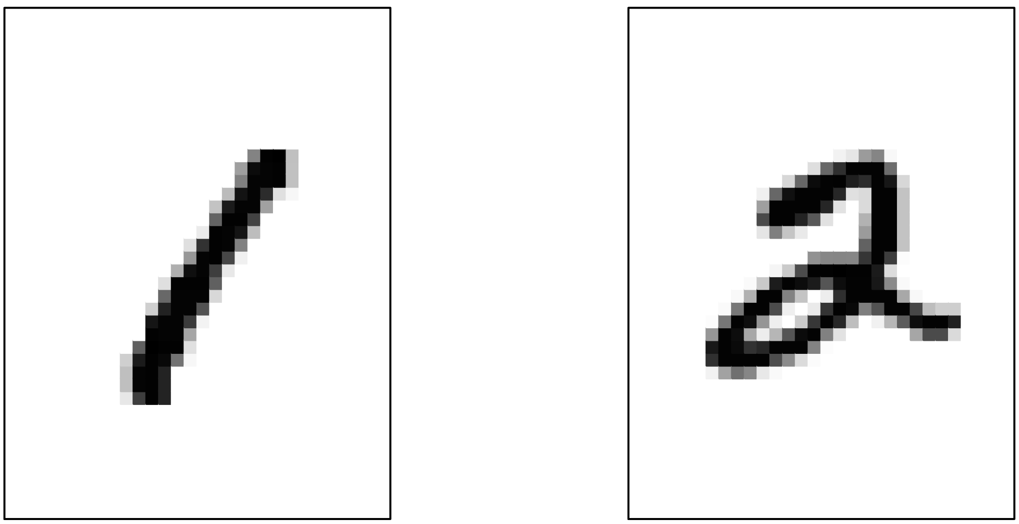


c)

```r
drawDigit <- function(m){
  initializeDigitPlot()
  for (x in 1:28){
    for (y in 1:28){
      drawBox(x,y,m[y,x]/255)
    }
  }
}
```

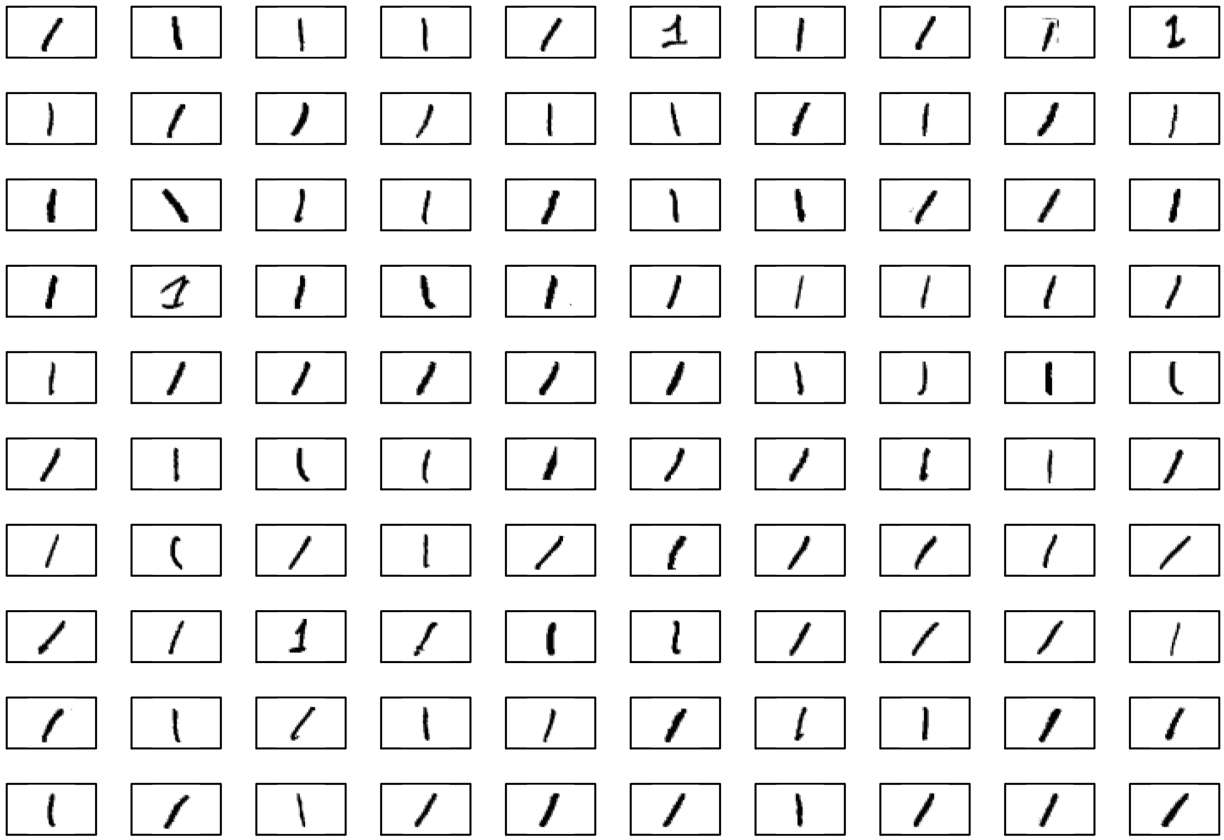
d)

```r
one=read.csv('one100.csv', header=T)
two=read.csv('two100.csv', header=T)
par(mfrow=c(1,2))
drawDigit(matrix(as.numeric(one[1,]), nrow=28))
drawDigit(matrix(as.numeric(two[1,]), nrow=28))
```



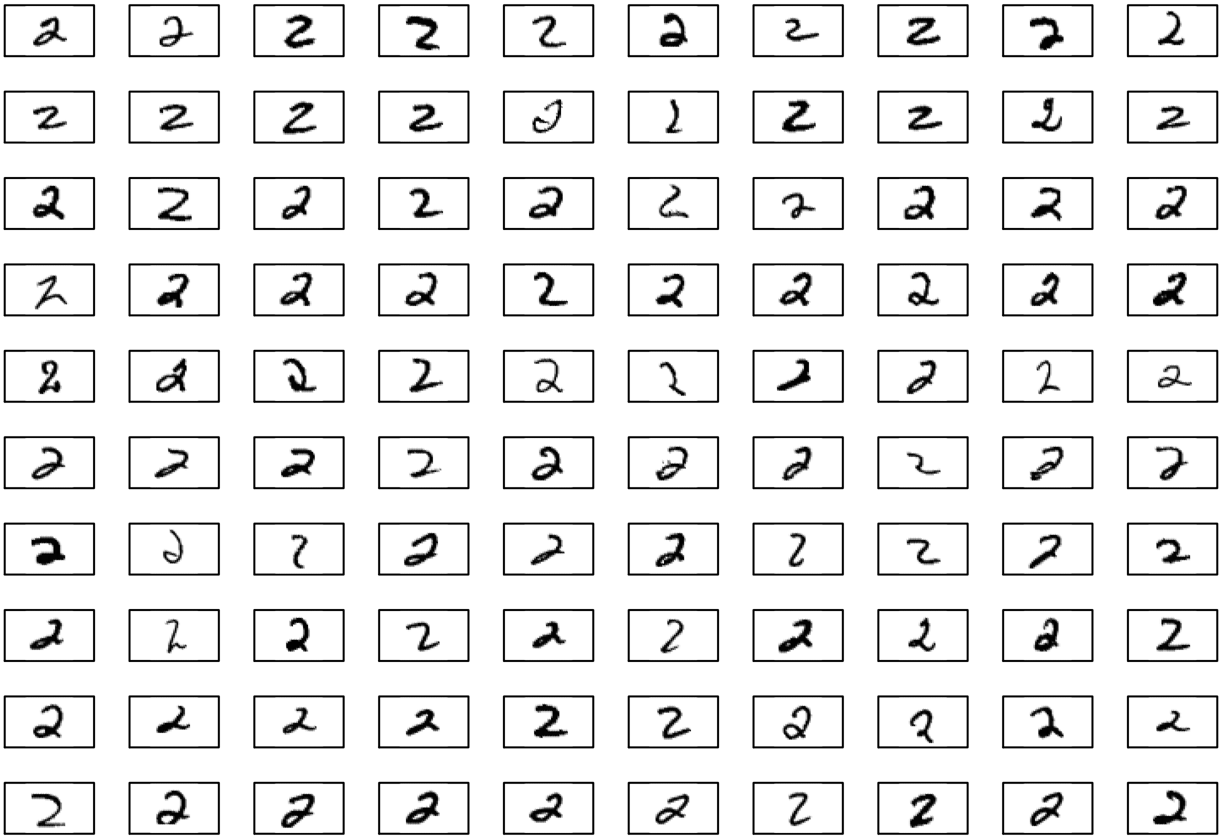
e)

```r
par(mfrow=c(10,10), mar=c(0.7,0.7,0.7,0.7))
for (r in 1:100){
  drawDigit(matrix(as.numeric(one[r,]),nrow=28))
}
```



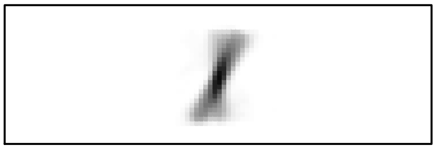
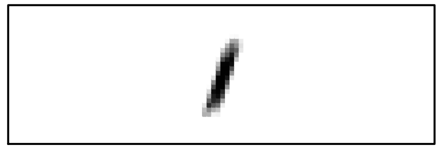
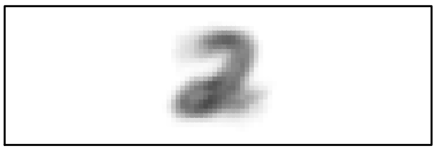
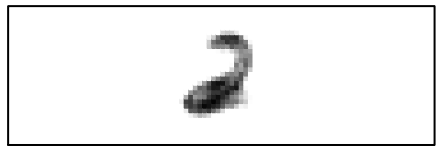
f)

```r
par(mfrow=c(10,10), mar=c(0.7,0.7,0.7,0.7))
for (r in 1:100){
  drawDigit(matrix(as.numeric(two[r,]),nrow=28))
}
```



g)

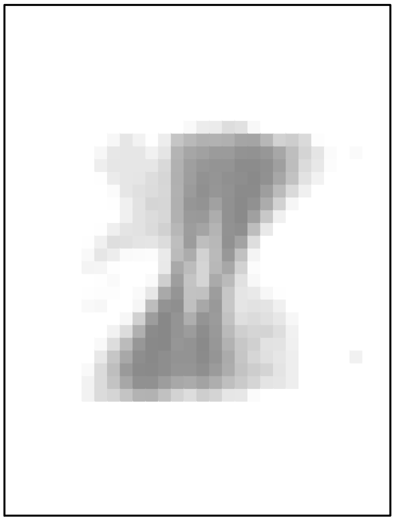
```
par(mfrow=c(2,2))
drawDigit(matrix(apply(one,2,mean),nrow=28))
drawDigit(matrix(apply(one,2,median),nrow=28))
drawDigit(matrix(apply(two,2,mean),nrow=28))
drawDigit(matrix(apply(two,2,median),nrow=28))
```

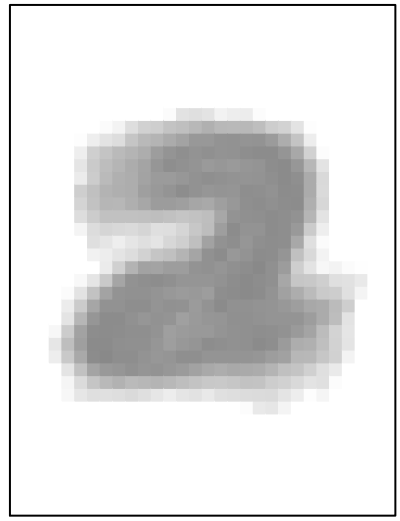





By taking both mean and median of two populations, we can see that the median contributes to a better image as a higher resolution is developed.

h)

```
par(mfrow=c(1,2))
drawDigit(matrix(apply(one,2,sd), nrow=28))
drawDigit(matrix(apply(two,2,sd), nrow=28))
```





Because both numbers on images are unclear, we can assume that they have some variabilities. However, from the shape, we can't easily tell what is on the first image. It might be a "Z". Th second image clearly shows a '2'. Therefore, we can conclude that the first population has a higher varaibility then the second population.