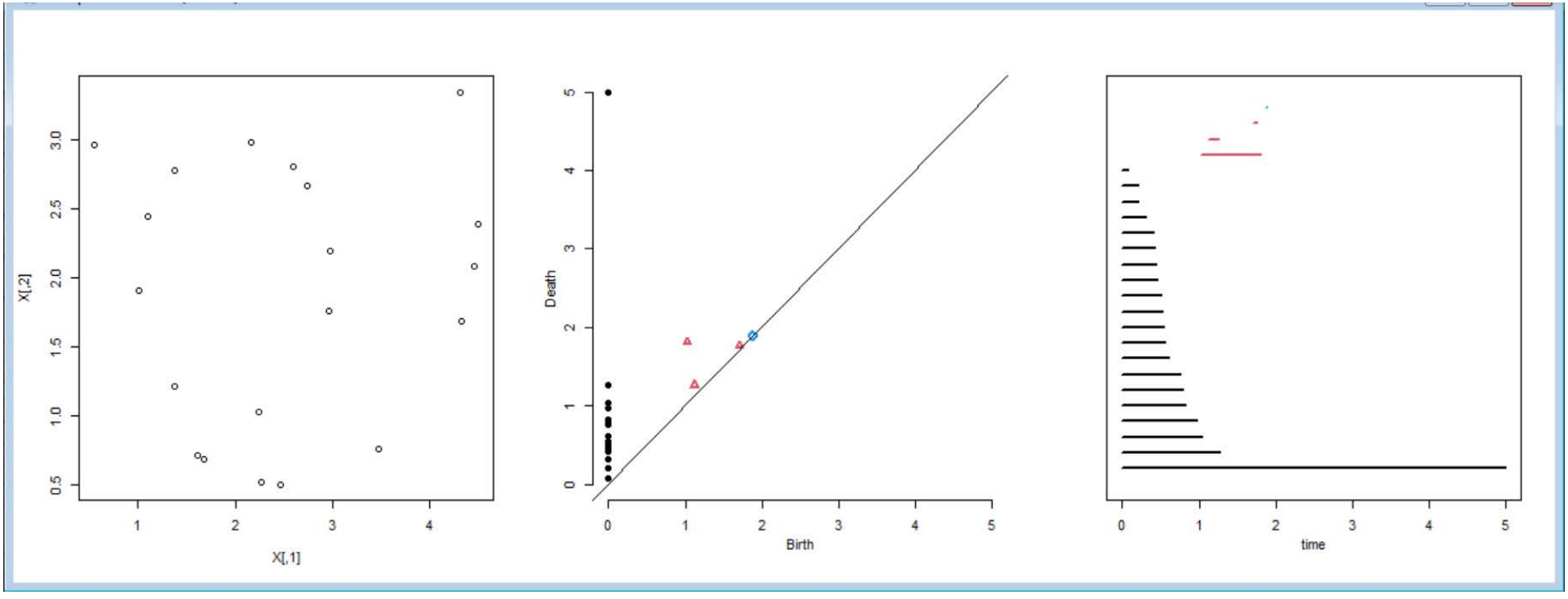
Topological Data Analysis

2022–2023

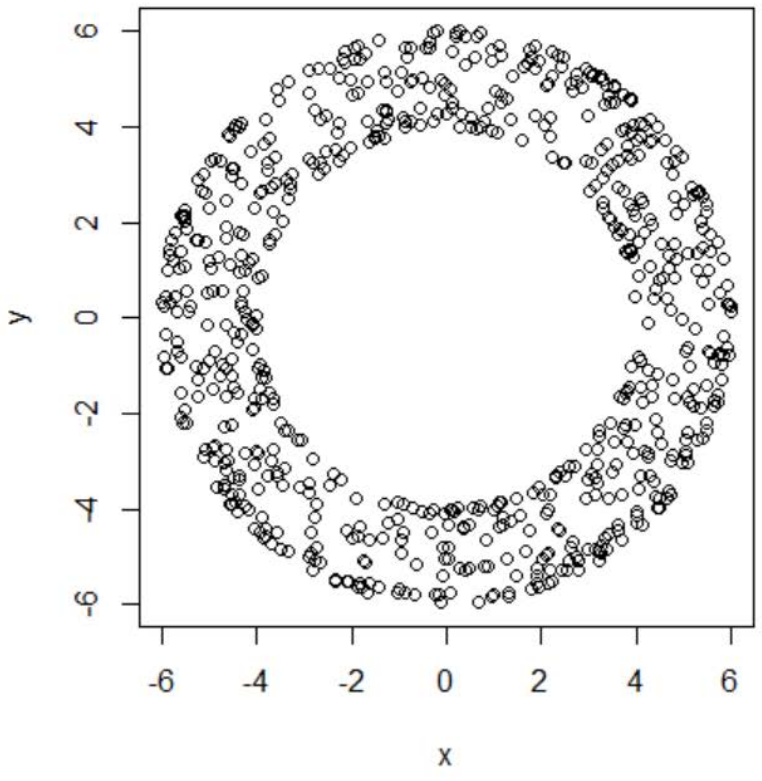
Examples with R

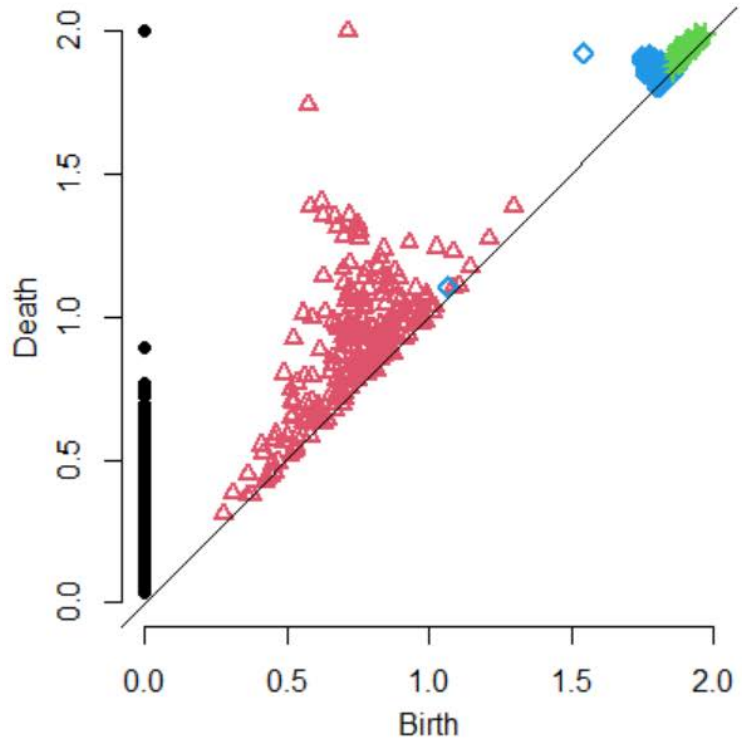
28 November 2022

```
library("TDA")
X1<-matrix(c(1.3793,1.2159,2.2406,1.0293,1.0039,1.9116,2.9802,2.1981,2.1629,2.9866,
1.3729,2.7789,2.9696,1.7553,1.1032,2.4425,2.5920,2.8059,2.7442,2.6679),ncol=2,byrow=TRUE)
X2<-matrix(c(4.4969,2.3893,2.2645,0.5139,1.6737,0.6786,4.3273,1.6869,3.4722,0.7522,
4.3107,3.3493,4.4554,2.0802,2.4653,0.5003,0.5548,2.9649,1.6062,0.7108),ncol=2,byrow=TRUE)
X<-rbind(X1,X2)
par(mfrow = c(1,3))
plot(X)
Diag<-ripsDiag(X,maxdimension=3,maxscale=5,library="GUDHI")
plot(Diag[["diagram"]],barcode=FALSE)
plot(Diag[["diagram"]],barcode=TRUE)
```

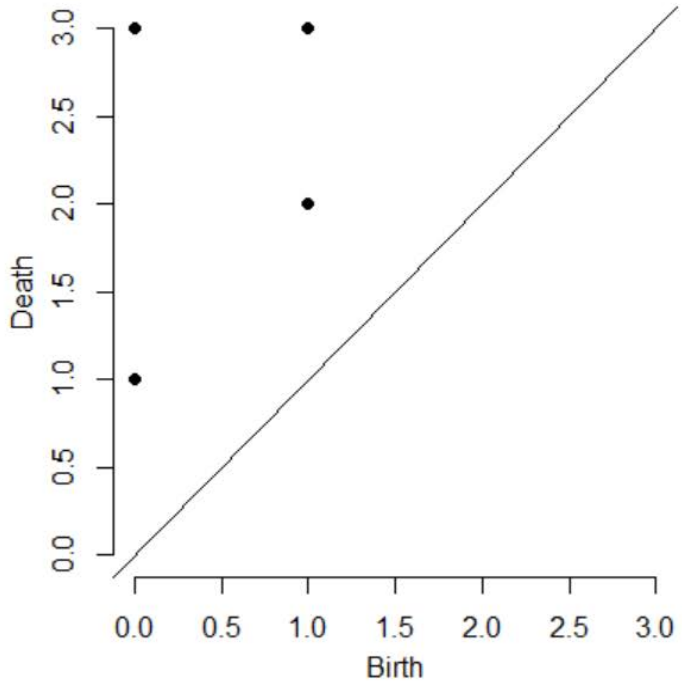


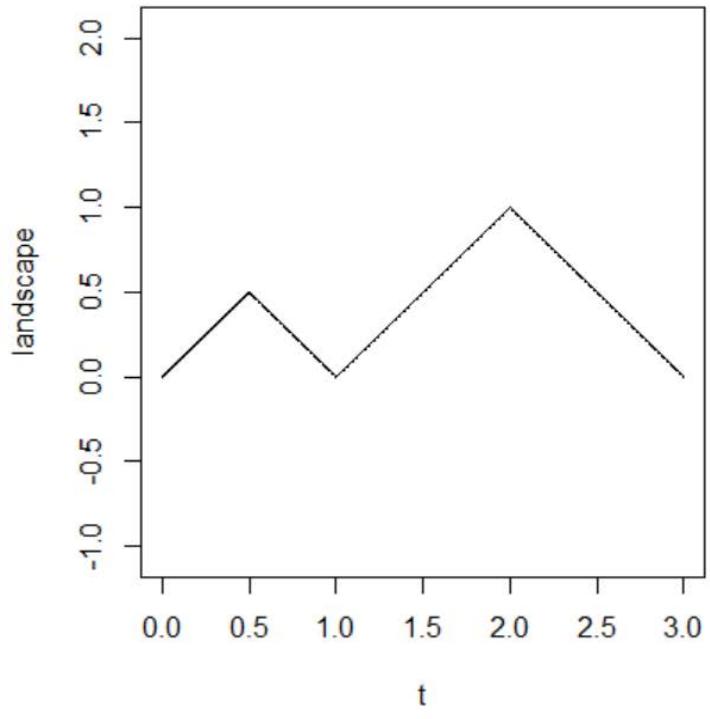
```
library("TDA")
Torus<-torusUnif(700,a=1,c=5)
Diag<-ripsDiag(Torus,maxdimension=3,maxscale=2,library="GUDHI")
par(mfrow = c(1,2))
plot(Torus)
plot.diagram(Diag[["diagram"]],barcode=FALSE)
```



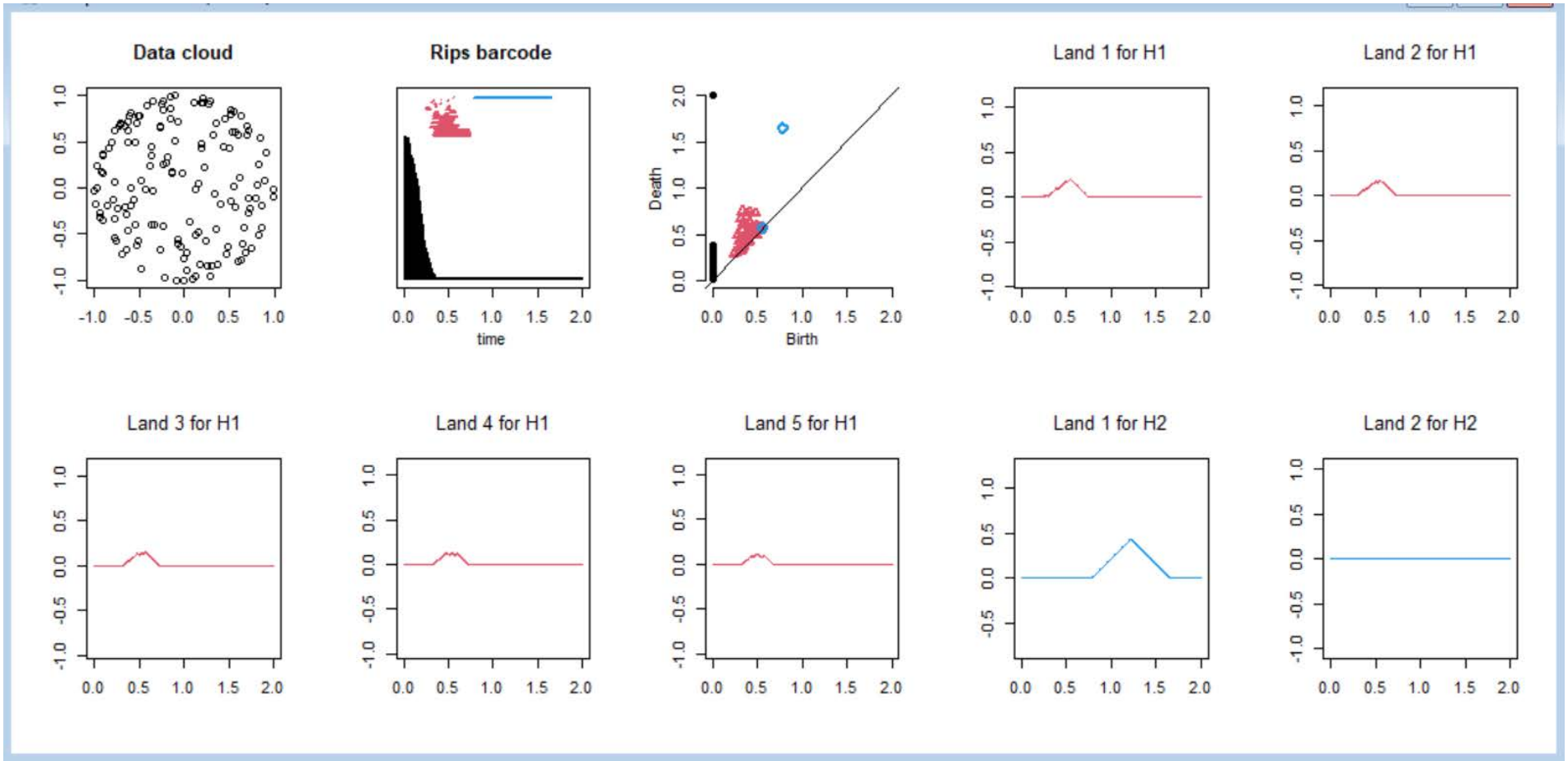


```
library("TDA")
Diag <- matrix(c(0, 0, 1, 0, 0, 3, 0, 1, 2, 0, 1, 3), ncol = 3, byrow = TRUE)
DiagLim <- 3
colnames(Diag) <- c("dimension", "Birth", "Death")
#persistence landscape
tseq <- seq(0,DiagLim, length = 1000)
Land <- landscape(Diag, dimension = 0, KK = 2, tseq)
par(mfrow = c(1,2))
plot.diagram(Diag)
plot(tseq, Land, type = "l", xlab = "t", ylab = "landscape", asp = 1)
```

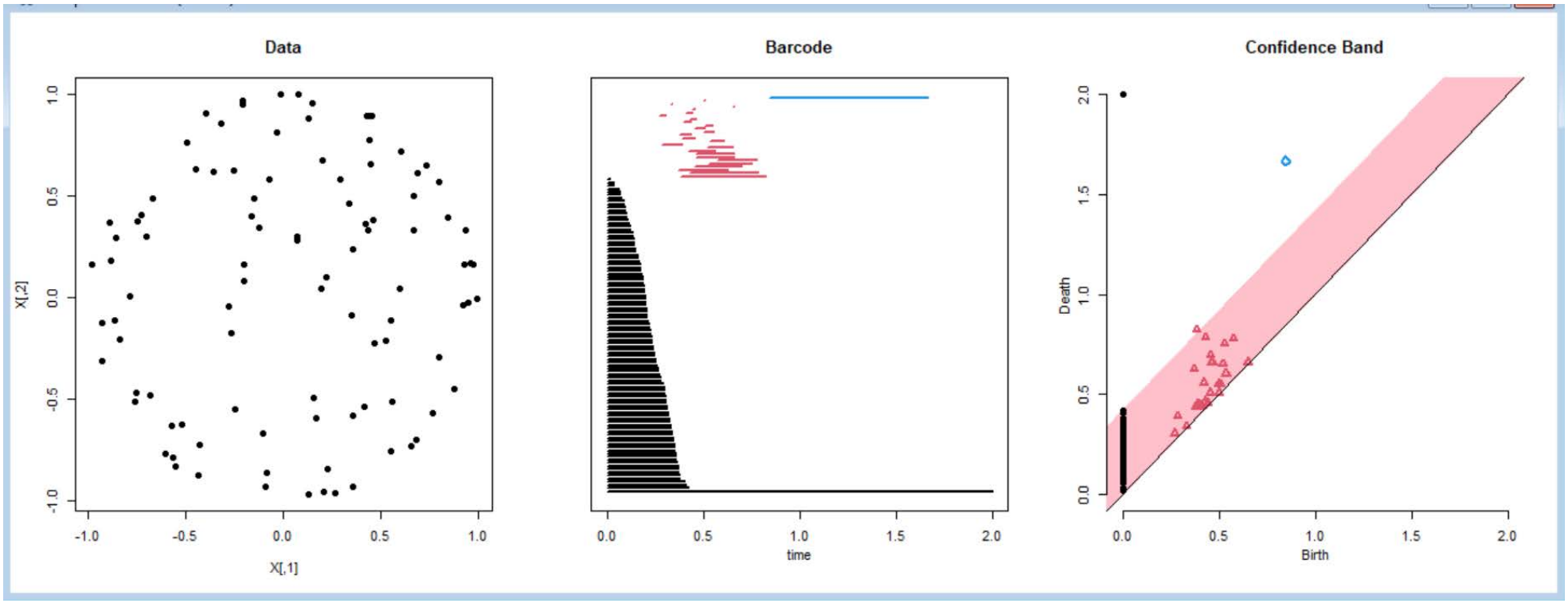




```
library("TDA")
X<-sphereUnif(n=150,d=2,r=1)
par(mfrow=c(2,5))
DiagLim<-2
Diag<-ripsDiag(X,maxdimension=2,maxscale=2,library="GUDHI")
plot(X,main="Data cloud",xlab="",ylab="")
plot(Diag[["diagram"]],barcode=TRUE,main="Rips barcode")
plot(Diag[["diagram"]])
tseq<-seq(0,DiagLim,length=1000)
for(i in 1:5)
{
Land1<-landscape(Diag[["diagram"]],dimension=1,KK=i,tseq)
plot(tseq,Land1,main=bquote(paste("Land ",.(i)," for H1")),
type="l",xlab="",ylab="",col=2,asp=1)
}
for(i in 1:2)
{
Land2<-landscape(Diag[["diagram"]],dimension=2,KK=i,tseq)
plot(tseq,Land2,main=bquote(paste("Land ",.(i)," for H2")),
type="l",xlab="",ylab="",col=4,asp=1)
}
```


Data cloud
Rips barcode
Land 1 for H1
Land 2 for H1
Land 3 for H1
Land 4 for H1
Land 5 for H1
Land 1 for H2
Land 2 for H2
Death
Birth
time

```
library("TDA")
X<-sphereUnif(n=100,d=2,r=1)
maxscale <- 2
maxdimension <- 2
DiagRips <- ripsDiag(
    X = X, maxdimension = maxdimension, maxscale = maxscale,
    library = "GUDHI", location = TRUE, printProgress = TRUE)
layout(matrix(c(1, 3, 2, 2), 2, 2))
DiagLim <- 2
maxdimension <- 2
tseq <- seq(0,DiagLim, length = 1000)
Xlim <- c(-1.6, 1.6); Ylim <- c(-1.6, 1.6); Zlim <- c(-1.6, 1.6); by <- 0.1
Xseq <- seq(Xlim[1], Xlim[2], by = by)
Yseq <- seq(Ylim[1], Ylim[2], by = by)
Zseq <- seq(Zlim[1], Zlim[2], by = by)
Grid <- expand.grid(Xseq, Yseq, Zseq)
distance <- distFct(X = X, Grid = Grid)
m0 <- 0.1
DTM <- dtm(X = X, Grid = Grid, m0 = m0)
k <- 100
kNN <- knnDE(X = X, Grid = Grid, k = k)
h <- 0.2
KDE <- kde(X = X, Grid = Grid, h = h)
Kdist <- kernelDist(X = X, Grid = Grid, h = h)
band <- bootstrapBand(X = X, FUN = kde, Grid = Grid,
B = 100, parallel = FALSE, alpha = 0.05, h = h)
DiagGrid <- gridDiag(X = X, FUN = kde, h = h, lim = cbind(Xlim, Ylim, Zlim),
by = by, sublevel = FALSE, library = "Dionysus", location = TRUE, printProgress = FALSE)
par(mfrow = c(1, 3))
plot(X, cex = 1, pch = 19, main = "Data")
plot(DiagRips[["diagram"]], barcode = TRUE, main = "Barcode")
plot.diagram(DiagRips[["diagram"]], rotated = FALSE, band = band[["width"]], main = "Confidence Band")
```


Data
X[,2]
X[,1]
-1.0
-0.5
0.0
0.5
1.0
Barcode
time
0.0
0.5
1.0
1.5
2.0
Confidence Band
Death
Birth
0.0
0.5
1.0
1.5
2.0

TDA Software

- **GUDHI** (*Geometry Understanding in Higher Dimensions*)
  http://gudhi.gforge.inria.fr
- **Dionysus**
  https://mrzv.org/software/dionysus2/
- **Ripser**
  https://live.ripser.org/
- The **R** package **TDAstats**
  https://cran.r-project.org/web/packages/TDAstats/index.html
- The **Matlab** library **JavaPlex**
  http://appliedtopology.github.io/javaplex/