ภาคผนวก

```
########################## Linear ###################################
rbf <- vanilladot()
Mksvm_Li <- ksvm(Class ~ ., data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_Li, index[-sample,]))
rbf <- vanilladot()
Mksvm_Li2 <- ksvm(Class ~ V1+V3+V10+V11+V41+V42+V49, data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_Li2, index[-sample,]))

########################## Poly 2 ###################################
rbf <- polydot(degree = 2, scale = 1.5, offset = 1)
Mksvm_P2 <- ksvm(Class ~ ., data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_P2, index[-sample,]))
rbf <- polydot(degree = 2, scale = 1.5, offset = 1)
Mksvm_P2_2 <- ksvm(Class ~ V1+V3+V10+V11+V41+V42+V49, data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_P2_2, index[-sample,]))

########################## Poly 3 ###################################
rbf <- polydot(degree = 3, scale = 1.5, offset = 1)
Mksvm_P3 <- ksvm(Class ~ ., data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_P3, index[-sample,]))
rbf <- polydot(degree = 3, scale = 1.5, offset = 1)
Mksvm_P3_2 <- ksvm(Class ~ V1+V3+V10+V11+V41+V42+V49, data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_P3_2, index[-sample,]))
```

```
########################## Poly 4 ###################################
rbf <- polydot(degree = 4, scale = 1.5, offset = 1)
Mksvm_P4 <- ksvm(Class ~ ., data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_P4, index[-sample,]))

rbf <- polydot(degree = 4, scale = 1.5, offset = 1)
Mksvm_P4_2 <- ksvm(Class ~ V1+V3+V10+V11+V41+V42+V49, data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_P4_2, index[-sample,]))

########################## Guassian ###################################
rbf <- rbfdot(sigma = 0.01)
Mksvm_G <- ksvm(Class ~ ., data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_G, index[-sample,]))

rbf <- rbfdot(sigma = 0.01)
Mksvm_G2 <- ksvm(Class ~ V1+V3+V10+V11+V41+V42+V49, data = id[sample,],type="C-
svc",kernel=rbf,C=20,cross=10,prob.model=TRUE)
table(index$Class[-sample], predict(Mksvm_G2, index[-sample,]))
```

ภาคผนวก ข

วิธีสเปกตรัมเคอร์เนลรวมกับวิธีของเค-เนียร์เรสต์เนเบอร์

กระบวนวิธีในจำแนกชนิดข้อมูลสายลำดับของโมเลกุลเอชแอลเอด้วยวิธีสเปกตรัมเคอร์เนลรวมกับวิธีของเค-เนียร์เรสต์เนเบอร์ และทำการเปรียบเทียบประสิทธิภาพกับวิธีการทันสมัยอื่นของกรณีศึกษาในบทที่ 5 สามารถแสดงให้เห็นทั้งหมดดังนี้

```
library(seqinr)
library(knnflex)
#########################Read fasta file#################################
A <- read.fasta('A_nuc.fasta', seqtype="DNA", as.string = TRUE)
B <- read.fasta('B_nuc.fasta', seqtype="DNA", as.string = TRUE)
C <- read.fasta('C_nuc.fasta', seqtype="DNA", as.string = TRUE)
E <- read.fasta('E_nuc.fasta', seqtype="DNA", as.string = TRUE)
F <- read.fasta('F_nuc.fasta', seqtype="DNA", as.string = TRUE)
G <- read.fasta('G_nuc.fasta', seqtype="DNA", as.string = TRUE)
DPA1 <- read.fasta('DPA1_nuc.fasta', seqtype="DNA", as.string = TRUE)
DPB1 <- read.fasta('DPB1_nuc.fasta', seqtype="DNA", as.string = TRUE)
DQA1 <- read.fasta('DQA1_nuc.fasta', seqtype="DNA", as.string = TRUE)
DQB1 <- read.fasta('DQB1_nuc.fasta', seqtype="DNA", as.string = TRUE)
DRB1 <- read.fasta('DRB1_nuc.fasta', seqtype="DNA", as.string = TRUE)
#################Idebtify number of each class and K-spectrum###########
nA <- length(A)
nB <- length(B)
nC <- length(C)
nE <- length(E)
nF <- length(F)
nG <- length(G)
```

```
nDPA1 <- length(DPA1)
nDPB1 <- length(DPB1)
nDQA1 <- length(DQA1)
nDQB1 <- length(DQB1)
nDRB1 <- length(DRB1)
aI <- c(A)
aII <- c(B)
aIII <- c(C)
aIV <- c(E)
aV <- c(F)
aVI <- c(G)
n_aI <- nA
n_aII <- nB
n_aIII <- nC
n_aIV <- nE
n_aV <- nF
n_aVI <- nG
bI <- c(DPA1)
bII <- c(DPB1)
bIII <- c(DQA1)
bIV <- c(DQB1)
bV <- c(DRB1)
n_bI <- nDPA1
n_bII <- nDPB1
n_bIII <- nDQA1
n_bIV <- nDQB1
n_bV <- nDRB1
nI <- nA+nB+nC+nE+nF+nG;
nII <- nDPA1 + nDPB1 + nDQA1 + nDQB1 + nDRB1;
n <- nI + nII;
```

```
cl <- factor(c(rep("aI",n_aI), rep("aII",n_aII), rep("aIII",n_aIII), rep("aIV",n_aIV),
        rep("aV",n_aV), rep("aVI",n_aVI), rep("bI",n_bI), rep("bII",n_bII), rep("bIII",n_bIII),
        rep("bIV",n_bIV), rep("bV",n_bV)));
sk <- stringdot(type="string", length=9)

###Calculate similarity score from SK for all possible relations of HLA genes##
D <- matrix(nrow = n, ncol = n);
### class 1      11,22,33,44,55,66 ###
for(i in 1: n_aI){
        D[i,i] <- 0;
        for(j in i: n_aI){
                D[i,j] <- 1 - sk(aI[[i]][1],aI[[j]][1]);
                D[j,i] <- D[i,j];
        }
}
for(i in 1: n_aII){
        D[i+n_aI,i+n_aI] <- 0;
        for(j in i: n_aII){
                D[i+n_aI,j+n_aI] <- 1 - sk(aII[[i]][1],aII[[j]][1]);
                D[j+n_aI,i+n_aI] <- D[i+n_aI,j+n_aI];
        }
}
for(i in 1: n_aIII){
        D[i+n_aI+n_aII,i+n_aI+n_aII] <- 0;
        for(j in i: n_aIII){
                D[i+n_aI+n_aII,j+n_aI+n_aII] <- 1 - sk(aIII[[i]][1],aIII[[j]][1]);
                D[j+n_aI+n_aII,i+n_aI+n_aII] <- D[i+n_aI+n_aII,j+n_aI+n_aII];
        }
}
```

```
for(i in 1: n_aIV){
        D[i+n_aI+n_aII+n_aIII,i+n_aI+n_aII+n_aIII] <- 0;
        for(j in i: n_aIV){
                D[i+n_aI+n_aII+n_aIII,j+n_aI+n_aII+n_aIII] <- 1 - sk(aIV[[i]][1],aIV[[j]][1]);
                D[j+n_aI+n_aII+n_aIII,i+n_aI+n_aII+n_aIII] <-
D[i+n_aI+n_aII+n_aIII,j+n_aI+n_aII+n_aIII];
        }
}
for(i in 1: n_aV){
        D[i+n_aI+n_aII+n_aIII+n_aIV,i+n_aI+n_aII+n_aIII+n_aIV] <- 0;
        for(j in i: n_aV){
                D[i+n_aI+n_aII+n_aIII+n_aIV,j+n_aI+n_aII+n_aIII+n_aIV] <- 1 -
sk(aV[[i]][1],aV[[j]][1]);
                D[j+n_aI+n_aII+n_aIII+n_aIV,i+n_aI+n_aII+n_aIII+n_aIV] <-
D[i+n_aI+n_aII+n_aIII+n_aIV,j+n_aI+n_aII+n_aIII+n_aIV];
        }
}
for(i in 1: n_aVI){
        D[i+n_aI+n_aII+n_aIII+n_aIV+n_aV,i+n_aI+n_aII+n_aIII+n_aIV+n_aV] <- 0;
        for(j in i: n_aVI){
                D[i+n_aI+n_aII+n_aIII+n_aIV+n_aV,j+n_aI+n_aII+n_aIII+n_aIV+n_aV] <- 1 -
sk(aVI[[i]][1],aVI[[j]][1]);
                D[j+n_aI+n_aII+n_aIII+n_aIV+n_aV,i+n_aI+n_aII+n_aIII+n_aIV+n_aV] <-
D[i+n_aI+n_aII+n_aIII+n_aIV+n_aV,j+n_aI+n_aII+n_aIII+n_aIV+n_aV];
        }
}
###class2          11,22,33,44,55 ###
for(i in 1 : n_bI){
        D[i+nI,j+nI] <- 0;
        for(j in 1 : n_bI){
```

```
                D[i+nI,j+nI] <- 1 - sk(bI[[i]][1],bI[[j]][1]);
                D[j+nI,i+nI] <- D[i+nI,j+nI];
        }
}
for(i in 1 : n_bII){
        D[nI+i+n_bI,nI+j+n_bI] <- 0;
        for(j in 1: n_bII){
                D[nI+i+n_bI,nI+j+n_bI] <- 1 - sk(bII[[i]][1],bII[[j]][1]);
                D[nI+j+n_bI,nI+i+n_bI] <- D[nI+i+n_bI,nI+j+n_bI];
        }
}
for(i in 1: n_bIII){
        D[nI+i+n_bI+n_bII,nI+j+n_bI+n_bII] <- 0;
        for(j in 1: n_bIII){
                D[nI+i+n_bI+n_bII,nI+j+n_bI+n_bII] <- 1 - sk(bIII[[i]][1],bIII[[j]][1]);
                D[nI+j+n_bI+n_bII,i+n_bI+n_bII] <- D[nI+i+n_bI+n_bII,nI+j+n_bI+n_bII];
        }
}
for(i in 1: n_bIV){
        D[nI+i+n_bI+n_bII+n_bIII,nI+j+n_bI+n_bII+n_bIII] <- 0;
        for(j in 1: n_bIV){
                D[nI+i+n_bI+n_bII+n_bIII,nI+j+n_bI+n_bII+n_bIII] <- 1 -
sk(bIV[[i]][1],bIV[[j]][1]);
                D[nI+j+n_bI+n_bII+n_bIII,nI+i+n_bI+n_bII+n_bIII] <-
D[nI+i+n_bI+n_bII+n_bIII,nI+j+n_bI+n_bII+n_bIII];
        }
}
for(i in 1: n_bV){
        D[nI+i+n_bI+n_bII+n_bIII+n_bIV,nI+j+n_bI+n_bII+n_bIII+n_bIV] <- 0;
        for(j in 1 : n_bV){
```

```
                D[nI+i+n_bI+n_bII+n_bIII+n_bIV,nI+j+n_bI+n_bII+n_bIII+n_bIV] <- 1 -
sk(bV[[i]][1],bV[[j]][1]);
                D[nI+j+n_bI+n_bII+n_bIII+n_bIV,nI+i+n_bI+n_bII+n_bIII+n_bIV] <-
D[nI+i+n_bI+n_bII+n_bIII+n_bIV,nI+j+n_bI+n_bII+n_bIII+n_bIV];
        }
}
###class1          12-16 ###
for(i in 1: n_aI){
        for(j in 1: n_aII){
                D[i,n_aI+j] <- 1 - sk(aI[[i]][1],aII[[j]][1]);
                D[n_aI+j,i] <- D[i,n_aI+j];
        }
}
for(i in 1: n_aI){
        for(j in 1: n_aIII){
                D[i,n_aI+n_aII+j] <- 1 - sk(aI[[i]][1],aIII[[j]][1]);
                D[n_aI+n_aII+j,i] <- D[i,n_aI+n_aII+j];
        }
}
for(i in 1: n_aI){
        for(j in 1: n_aIV){
                D[i,n_aI+n_aII+n_aIII+j] <- 1 - sk(aI[[i]][1],aIV[[j]][1]);
                D[n_aI+n_aII+n_aIII+j,i] <- D[i,n_aI+n_aII+n_aIII+j];
        }
}
for(i in 1: n_aI){
        for(j in 1: n_aV){
                D[i,n_aI+n_aII+n_aIII+n_aIV+j] <- 1 - sk(aI[[i]][1],aV[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+j,i] <- D[i,n_aI+n_aII+n_aIII+n_aIV+j];
        }
```

```
}
for(i in 1: n_aI){
        for(j in 1: n_aVI){
                D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j] <- 1 - sk(aI[[i]][1],aVI[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+n_aV+j,i] <-
D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j];
        }
}
###class2          12-15 ###
for(i in 1: n_bI){
        for(j in 1: n_bII){
                D[nI+i,nI+n_bI+j] <- 1 - sk(bI[[i]][1],bII[[j]][1]);
                D[nI+n_bI+j,nI+i] <- D[nI+i,nI+n_bI+j];
        }
}
 for(i in 1: n_bI){
        for(j in 1: n_bIII){
                D[nI+i,nI+n_bI+n_bII+j] <- 1 - sk(bI[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,nI+i] <- D[nI+i,nI+n_bI+n_bII+j];
        }
 }
 for(i in 1: n_bI){
        for(j in 1: n_bIV){
                D[nI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 - sk(bI[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,nI+i] <- D[nI+i,nI+n_bI+n_bII+n_bIII+j];
        }
 }
 for(i in 1: n_bI){
        for(j in 1: n_bV){
                D[nI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 - sk(bI[[i]][1],bV[[j]][1]);
```

```
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,nI+i] <-
D[nI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class1        23-26 ###
for(i in 1: n_aII){
        for(j in 1: n_aIII){
                D[i,n_aI+n_aII+j] <- 1 - sk(aII[[i]][1],aIII[[j]][1]);
                D[n_aI+n_aII+j,i] <- D[i,n_aI+n_aII+j];
        }
}
for(i in 1: n_aII){
        for(j in 1: n_aIV){
                D[i,n_aI+n_aII+n_aIII+j] <- 1 - sk(aII[[i]][1],aIV[[j]][1]);
                D[n_aI+n_aII+n_aIII+j,i] <- D[i,n_aI+n_aII+n_aIII+j];
        }
}
for(i in 1: n_aII){
        for(j in 1: n_aV){
                D[i,n_aI+n_aII+n_aIII+n_aIV+j] <- 1 - sk(aII[[i]][1],aV[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+j,i] <- D[i,n_aI+n_aII+n_aIII+n_aIV+j];
        }
}
for(i in 1: n_aII){
        for(j in 1: n_aVI){
                D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j] <- 1 - sk(aII[[i]][1],aVI[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+n_aV+j,i] <-
D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j];
        }
}
```

```
###class2          23-25 ###
for(i in 1: n_bII){
        for(j in 1: n_bIII){
                D[nI+n_bI+i,nI+n_bI+n_bII+j] <- 1 - sk(bII[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,nI+n_bI+i] <- D[nI+n_bI+i,nI+n_bI+n_bII+j];
        }
}
for(i in 1: n_bII){
        for(j in 1: n_bIV){
                D[nI+n_bI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 - sk(bII[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,nI+n_bI+i] <-
D[nI+n_bI+i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1: n_bII){
        for(j in 1: n_bV){
                D[nI+n_bI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 - sk(bII[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,nI+n_bI+i] <-
D[nI+n_bI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class1          34-36 ###
for(i in 1: n_aIII){
        for(j in 1: n_aIV){
                D[i,n_aI+n_aII+n_aIII+j] <- 1 - sk(aIII[[i]][1],aIV[[j]][1]);
                D[n_aI+n_aII+n_aIII+j,i] <- D[i,n_aI+n_aII+n_aIII+j];
        }
}
for(i in 1: n_aIII){
        for(j in 1: n_aV){
```

```
                D[i,n_aI+n_aII+n_aIII+n_aIV+j] <- 1 - sk(aIII[[i]][1],aV[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+j,i] <- D[i,n_aI+n_aII+n_aIII+n_aIV+j];
        }
}
for(i in 1: n_aIII){
        for(j in 1: n_aVI){
                D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j] <- 1 - sk(aIII[[i]][1],aVI[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+n_aV+j,i] <-
D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j];
        }
}
###class2        34-35 ###
for(i in 1: n_bIII){
        for(j in 1: n_bIV){
                D[nI+n_bI+n_bII+i,nI+n_bI+n_bII+n_bIII+j] <- 1 - sk(bIII[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,nI+n_bI+n_bII+i] <-
D[nI+n_bI+n_bII+i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1: n_bIII){
        for(j in 1: n_bV){
                D[nI+n_bI+n_bII+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 -
sk(bIII[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,nI+n_bI+n_bII+i] <-
D[nI+n_bI+n_bII+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class1        45-46 ###
for(i in 1: n_aIV){
        for(j in 1: n_aV){
```

```
                D[i,n_aI+n_aII+n_aIII+n_aIV+j] <- 1 - sk(aIV[[i]][1],aV[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+j,i] <- D[i,n_aI+n_aII+n_aIII+n_aIV+j];
        }
}
for(i in 1: n_aIV){
        for(j in 1: n_aVI){
                D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j] <- 1 - sk(aIV[[i]][1],aVI[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+n_aV+j,i] <-
D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j];
        }
}
###class2          45 ###
for(i in nI+1: nI+1+n_bIV){
        for(j in nI+1: nI+1+n_bV){
                D[i,n_bI+n_bII+n_bIII+n_bIV+j] <- 1 - sk(bIV[[i]][1],bV[[j]][1]);
                D[n_bI+n_bII+n_bIII+n_bIV+j,i] <- D[i,n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class1          56 ###
for(i in 1: n_aV){
        for(j in 1: n_aVI){
                D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j] <- 1 - sk(aV[[i]][1],aVI[[j]][1]);
                D[n_aI+n_aII+n_aIII+n_aIV+n_aV+j,i] <-
D[i,n_aI+n_aII+n_aIII+n_aIV+n_aV+j];
        }
}
###class          a1-b(1-5)          ####
for(i in 1 : n_aI ){
        for(j in 1: n_bI){
                D[i,nI+j] <- 1 - sk(aI[[i]][1],bI[[j]][1]);
```

```
                D[nI+j,i] <- D[i,nI+j];
        }
}
for(i in 1 : n_aI ){
        for(j in 1: n_bII){
                D[i,nI+n_bI+j] <- 1 - sk(aI[[i]][1],bII[[j]][1]);
                D[nI+n_bI+j,i] <- D[i,nI+n_bI+j];
        }
}
for(i in 1 : n_aI ){
        for(j in 1: n_bIII){
                D[i,nI+n_bI+n_bII+j] <- 1 - sk(aI[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,i] <- D[i,nI+n_bI+n_bII+j];
        }
}
for(i in 1 : n_aI ){
        for(j in 1: n_bIV){
                D[i,nI+n_bI+n_bII+n_bIII+j] <- 1 - sk(aI[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,i] <- D[i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1 : n_aI ){
        for(j in 1: n_bV){
                D[i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 - sk(aI[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,i] <- D[i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class          a2-b(1-5)          ####
for(i in 1 : n_aII ){
        for(j in 1: n_bI){
```

```
                D[n_aI+i,nI+j] <- 1 - sk(aII[[i]][1],bI[[j]][1]);
                D[nI+j,n_aI+i] <- D[n_aI+i,nI+j];
        }
}
for(i in 1 : n_aII ){
        for(j in 1: n_bII){
                D[n_aI+i,nI+n_bI+j] <- 1 - sk(aII[[i]][1],bII[[j]][1]);
                D[nI+n_bI+j,n_aI+i] <- D[n_aI+i,nI+n_bI+j];
        }
}
for(i in 1 : n_aII ){
        for(j in 1: n_bIII){
                D[n_aI+i,nI+n_bI+n_bII+j] <- 1 - sk(aII[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,n_aI+i] <- D[n_aI+i,nI+n_bI+n_bII+j];
        }
}
for(i in 1 : n_aII ){
        for(j in 1: n_bIV){
                D[n_aI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 - sk(aII[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,n_aI+i] <- D[n_aI+i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1 : n_aII ){
        for(j in 1: n_bV){
                D[n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 - sk(aII[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,n_aI+i] <-
D[n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
```

```
###class          a3-b(1-5)          ####
for(i in 1 : n_aIII ){
        for(j in 1: n_bI){
                D[n_aII+n_aI+i,nI+j] <- 1 - sk(aIII[[i]][1],bI[[j]][1]);
                D[nI+j,n_aII+n_aI+i] <- D[n_aII+n_aI+i,nI+j];
        }
}
for(i in 1 : n_aIII ){
        for(j in 1: n_bII){
                D[n_aII+n_aI+i,nI+n_bI+j] <- 1 - sk(aIII[[i]][1],bII[[j]][1]);
                D[nI+n_bI+j,n_aII+n_aI+i] <- D[n_aII+n_aI+i,nI+n_bI+j];
        }
}
for(i in 1 : n_aIII ){
        for(j in 1: n_bIII){
                D[n_aII+n_aI+i,nI+n_bI+n_bII+j] <- 1 - sk(aIII[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,n_aII+n_aI+i] <- D[n_aII+n_aI+i,nI+n_bI+n_bII+j];
        }
}
for(i in 1 : n_aIII ){
        for(j in 1: n_bIV){
                D[n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 - sk(aIII[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,n_aII+n_aI+i] <-
D[n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1 : n_aIII ){
        for(j in 1: n_bV){
                D[n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 - sk(aI[[i]][1],bV[[j]][1]);
```

```
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,n_aII+n_aI+i] <-
D[n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class         a4-b(1-5)       ####
for(i in 1 : n_aIV ){
        for(j in 1: n_bI){
                D[n_aIII+n_aII+n_aI+i,nI+j] <- 1 - sk(aIV[[i]][1],bI[[j]][1]);
                D[nI+j,n_aIII+n_aII+n_aI+i] <- D[n_aIII+n_aII+n_aI+i,nI+j];
        }
}
for(i in 1 : n_aIV ){
        for(j in 1: n_bII){
                D[n_aIII+n_aII+n_aI+i,nI+n_bI+j] <- 1 - sk(aIV[[i]][1],bII[[j]][1]);
                D[nI+n_bI+j,n_aIII+n_aII+n_aI+i] <- D[n_aIII+n_aII+n_aI+i,nI+n_bI+j];
        }
}
for(i in 1 : n_aIV ){
        for(j in 1: n_bIII){
                D[n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+j] <- 1 - sk(aIV[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,n_aIII+n_aII+n_aI+i] <-
D[n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+j];
        }
}
for(i in 1 : n_aIV ){
        for(j in 1: n_bIV){
                D[n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 -
sk(aIV[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,n_aIII+n_aII+n_aI+i] <-
D[n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j];
```

```
        }
}
for(i in 1 : n_aIV ){
        for(j in 1: n_bV){
                D[n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 -
sk(aIV[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,n_aIII+n_aII+n_aI+i] <-
D[n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class         a5-b(1-5)       ####
for(i in 1 : n_aV ){
        for(j in 1: n_bI){
                D[n_aIV+n_aIII+n_aII+n_aI+i,nI+j] <- 1 - sk(aV[[i]][1],bI[[j]][1]);
                D[nI+j,n_aIV+n_aIII+n_aII+n_aI+i] <- D[n_aIV+n_aIII+n_aII+n_aI+i,nI+j];
        }
}
for(i in 1 : n_aV ){
        for(j in 1: n_bII){
                D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+j] <- 1 - sk(aV[[i]][1],bII[[j]][1]);
                D[nI+n_bI+j,n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+j];
        }
}
for(i in 1 : n_aV ){
        for(j in 1: n_bIII){
                D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+j] <- 1 -
sk(aV[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+j];
```

```
        }
}
for(i in 1 : n_aV ){
        for(j in 1: n_bIV){
                D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 -
sk(aV[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1 : n_aV ){
        for(j in 1: n_bV){
                D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 -
sk(aV[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
###class          a6-b(1-5)       ####
for(i in 1 : n_aVI ){
        for(j in 1: n_bI){
                D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+j] <- 1 - sk(aVI[[i]][1],bI[[j]][1]);
                D[nI+j,n_aV+n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+j];
        }
}
for(i in 1 : n_aVI ){
        for(j in 1: n_bII){
                D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+j] <- 1 -
sk(aVI[[i]][1],bII[[j]][1]);
```

```
                D[nI+n_bI+j,n_aV+n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+j];
        }
}
for(i in 1 : n_aVI ){
        for(j in 1: n_bIII){
                D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+j] <- 1 -
sk(aVI[[i]][1],bIII[[j]][1]);
                D[nI+n_bI+n_bII+j,n_aV+n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+j];
        }
}
for(i in 1 : n_aVI ){
        for(j in 1: n_bIV){
                D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j] <- 1 -
sk(aVI[[i]][1],bIV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+j,n_aV+n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+j];
        }
}
for(i in 1 : n_aVI ){
        for(j in 1: n_bV){
                D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j] <- 1 -
sk(aI[[i]][1],bV[[j]][1]);
                D[nI+n_bI+n_bII+n_bIII+n_bIV+j,n_aV+n_aIV+n_aIII+n_aII+n_aI+i] <-
D[n_aV+n_aIV+n_aIII+n_aII+n_aI+i,nI+n_bI+n_bII+n_bIII+n_bIV+j];
        }
}
```

```
##################Cross-validation############################
fold<-sample(1:10,nI,replace=TRUE)
cvpred<-matrix(NA,nrow=nI,ncol=3)
for(k in 1:3)
        for(i in 1:10)
                cvpred[which(fold==i),k]<-
knn.predict(train=which(fold!=i),test=which(fold==i),cl,D,k=3,agg.meth="majority");


apply(cvpred,2,function(x)sum(cl!=x))
```

ประวัติผู้เขียน

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ผลงานวิจัย	P. Mekha, W. Shoombuatong, J. Chaijaruwanich "Spectrum Kernel Approach for Human Leukocyte Antigen Genes Classification." In Proceeding of the 2011 15th International Annual Symposium on Computational Science and Engineering (ANSCSE15).