Judge Bias Analysis

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Step 1: Get Judge Information(Name & Country)

```
data <- read.csv(file="Diving2012_ch835_mk2297.csv", as.is = TRUE)
UniRef <- data.frame(Judge=unique(data$Judge), JCountry=rep(NA,length(unique(data$Judge))))
UniRef$JCountry <- apply(as.matrix(UniRef$Judge),1,function(x) data$JCountry[which(data$Judge==x)[1]])
```

Step 2: Analysis of Judging Bias by T-test

Main ideas dedicated to the MathHorizons paper. Define Judge Bias as "a biased judge is one who awards higher scores than other judges to his own countrymen, but fails to award higher scores to non-countrymen".

```
# Match the nationality of judges and divers
data$match <- data$Country == data$JCountry

# Calculate untrimmed mean, showing a judge's tendency to differ from other judges
temp <- tapply(as.numeric(data$JScore),rep(1:(nrow(data)/7), each=7), mean)
data$avg <- rep(temp, each=7)
# Calculate the difference between a particular judge's score and the untrimmed mean
data$discrepancy <- as.numeric(data$JScore) - data$avg

# Find judges whose nationality matched that of the particular diver.
ismatch <- apply(as.matrix(UniRef[,1]),1,function(x) sum(data$match[data$Judge==x])>0)
UniRef$p.value <- rep(0, length(ismatch))
UniRef$ADmatch <- rep(0, length(ismatch))
UniRef$ADnomatch <- rep(0, length(ismatch))

# Judge loop begins here
for (thisjudge in UniRef[ismatch,1]) {
  y <- data[data$Judge==thisjudge,]
  # T-test assuming judges bias towards their own countrymen
  # H0: no bias
  # H1: bias
  test <- t.test(y$discrepancy[y$match],y$discrepancy[!y$match], alternative="great")
  UniRef[UniRef[,1]==thisjudge, 3] <- test$p.value
  UniRef[UniRef[,1]==thisjudge, 4] <- mean(y$discrepancy[y$match])
  UniRef[UniRef[,1]==thisjudge, 5] <- mean(y$discrepancy[!y$match],na.rm = TRUE)
}
```

Step 3: Produce Main Table of Results.

```
library("xtable")
# Paste judge name and country into one column
```

```
UniRef[,6] <- paste(UniRef[,1]," (",UniRef[,2],")",sep="")
UniRef[,6] <- gsub("[A-Z]( [A-Z][a-z]+)",",\\1",UniRef[,6])
UniRef <- UniRef[ismatch,]
# Find number of Matched Dives
matchnum <- apply(as.matrix(UniRef[, 1]), 1, function(x) sum(data$match[data$Judge==x]))
# Find number of Non-Matched Dives
nonmatchnum <- apply(as.matrix(UniRef[, 1]), 1, function(x) sum(data$match[data$Judge!= x]))
# Create the table of results
mytable <- data.frame(UniRef[, 6],  matchnum, UniRef$ADmatch, nonmatchnum,
                      UniRef$ADnomatch,UniRef[, 4]-UniRef[, 5],UniRef$p.value)
names(mytable)<- c("Judge", "Number of Matched Dives", "Average Discrepancy for Matched Dives",
                   "Number of Non-Matched Dives", "Average Discrepancy for Non-Matched Dives",
                   "Difference of Average Discrepancies(DoAD)", "p-value")
yourtable <- xtable(mytable, hline.after=c(-1, 0), align= c("|c|", "p{0.3\\textwidth}|", "p{0.07\\textw
print(yourtable, include.rownames = FALSE )
```

% latex table generated in R 3.3.2 by xtable 1.8-2 package % Tue Nov 01 03:08:14 2016

```
# Please see the table on the last page.
```

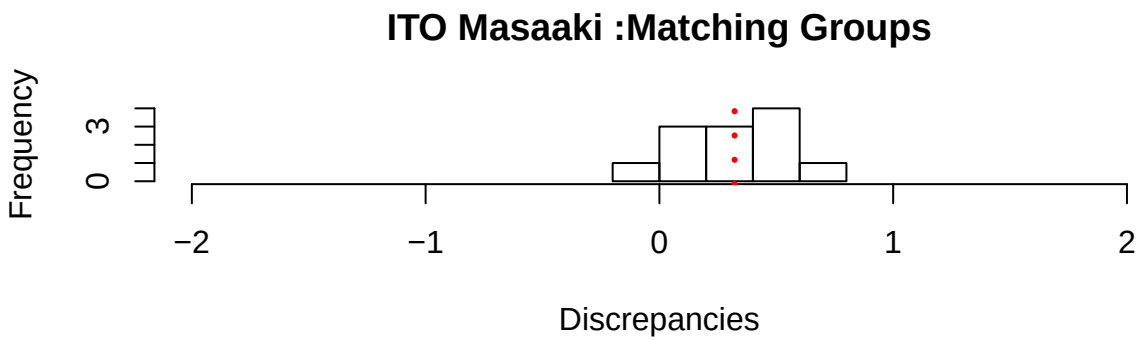
Step 4: Analysis of the Results

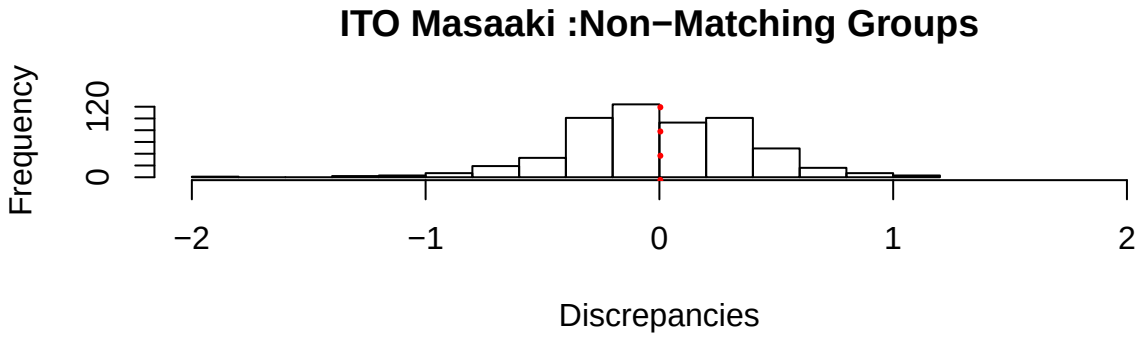
```
# Find the most and least biased judges according to p-value
# High p-values indicate the discrepancy is likely assuming judge had been unbiased.
# So the higher the p-value is, the least biased a judge is.

# Find the most biased judge with lowest p-value
ind0 <- UniRef$Judge[which.min(mytable$`p-value`)]
y <- data[data$Judge == ind0,]; as.character(ind0)
```

```
## [1] "ITO Masaaki"
```

```
par(mfrow=c(2,1))
hist(y$discrepancy[y$match],
     main=paste(UniRef$Judge[which.min(mytable$`p-value`)],":Matching Groups"),
     xlab="Discrepancies", xlim=c(-2,2))
abline(v=mean(y$discrepancy[y$match],na.rm = TRUE),col="red",lwd=3,lty=3)
hist(y$discrepancy[!y$match],
     main=paste(UniRef$Judge[which.min(mytable$`p-value`)],":Non-Matching Groups"),
     xlab="Discrepancies", xlim=c(-2,2))
abline(v=mean(y$discrepancy[!y$match],na.rm = TRUE),col="red",lwd=3,lty=3)
```

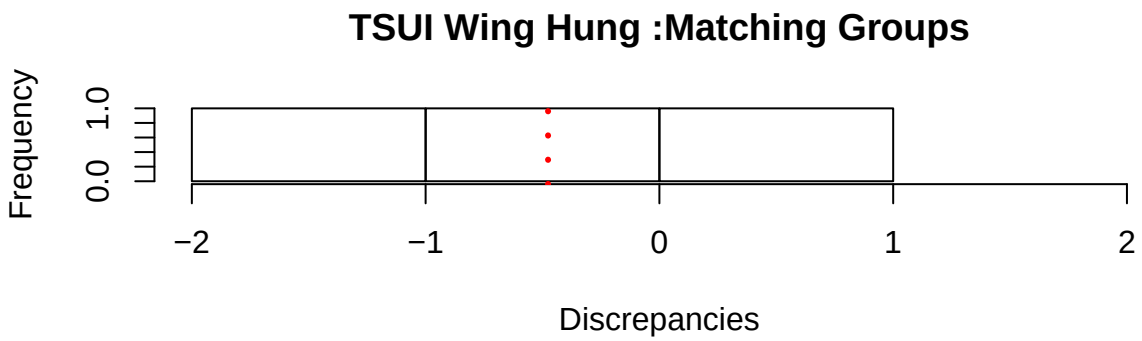


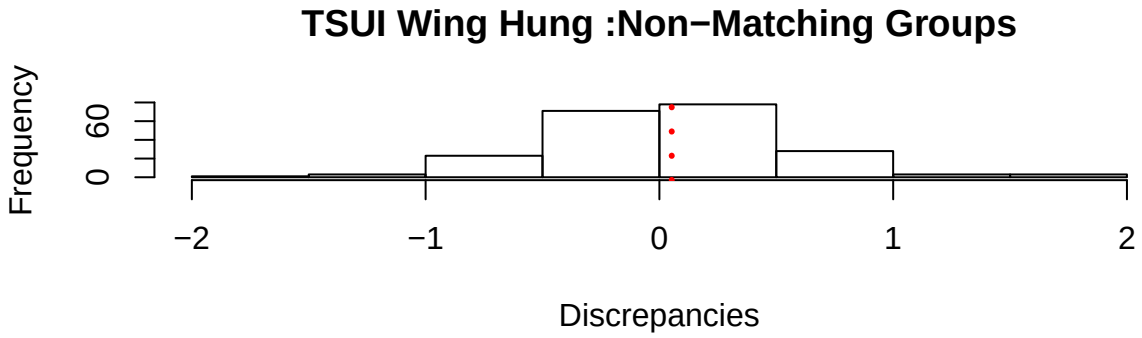



```
# Find the least biased judge with highest p-value
ind2 <- UniRef$Judge[which.max(mytable$`p-value`)]
y2 <- data[data$Judge == ind2,]; as.character(ind2)
```

```
## [1] "TSUI Wing Hung"
```

```
hist(y2$discrepancy[y2$match],
     main=paste(UniRef$Judge[which.max(mytable$`p-value`)],":Matching Groups"),
     xlab="Discrepancies", xlim=c(-2,2))
abline(v=mean(y2$discrepancy[y2$match],na.rm = TRUE),col="red",lwd=3,lty=3)
hist(y2$discrepancy[!y2$match],
     main=paste(UniRef$Judge[which.max(mytable$`p-value`)],":Non-Matching Groups"),
     xlab="Discrepancies", xlim=c(-2,2))
abline(v=mean(y2$discrepancy[!y2$match],na.rm = TRUE),col="red",lwd=3,lty=3)
```

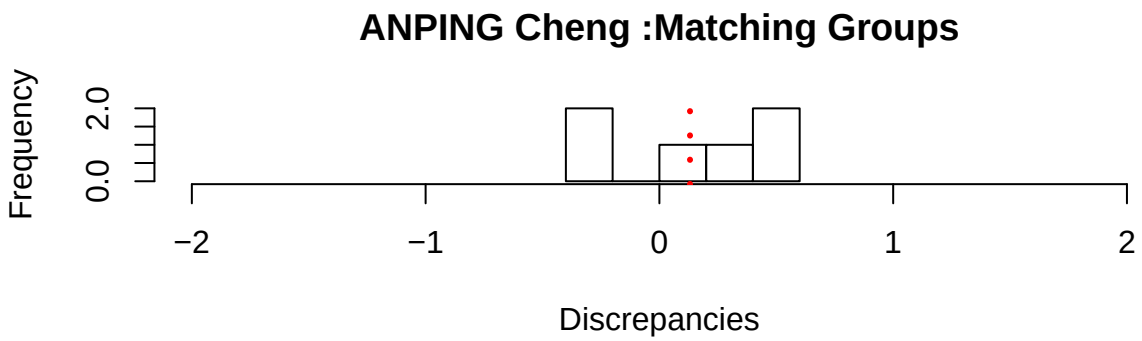


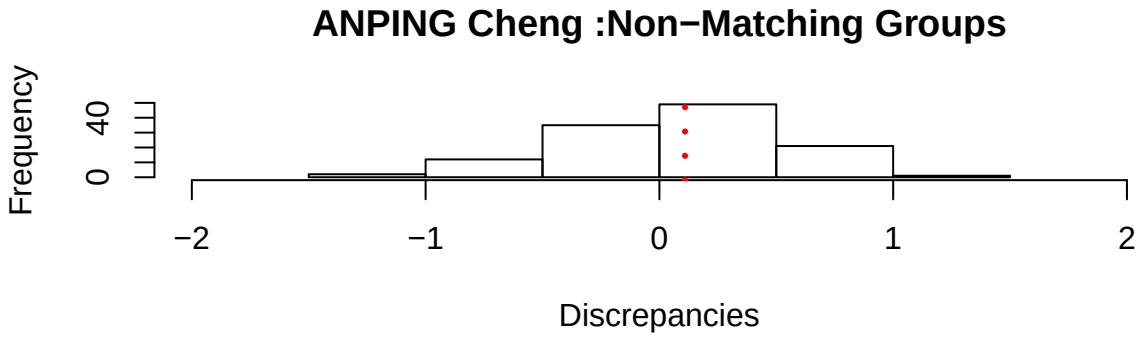



```
# We assume that judges bias towards their own country, but the least biased judge is not biased toward
# country according to the histogram.
# So next we find the least biased judge toward his own country by limiting DoAd > 0
ind3 <- which(mytable[,6]>0)
y3 <- data[data$Judge==UniRef$Judge[ind3][which.max(mytable$`p-value`[ind3])],];
y3$Judge[1]
```

```
## [1] "ANPING Cheng"
```

```
hist(y3$discrepancy[y3$match],
     main=paste(UniRef$Judge[ind3][which.max(mytable$`p-value`[ind3])],":Matching Groups"), xlab="Discr
     xlim=c(-2,2))
abline(v=mean(y3$discrepancy[y3$match],na.rm = TRUE),col="red",lwd=3,lty=3)
hist(y3$discrepancy[!y3$match],
     main=paste(UniRef$Judge[ind3][which.max(mytable$`p-value`[ind3])],":Non-Matching Groups"), xlab="D
abline(v=mean(y3$discrepancy[!y3$match],na.rm = TRUE),col="red",lwd=3,lty=3)
```






```
# The proportion of p-values < 0.1
sum(mytable$`p-value`< 0.1) /dim(mytable)[1]
```

```
## [1] 0.4375
```

```
# It reveals that nationalistic bias was prevalent in 2012 Olympic diving Competition
```

Judge	Number of Matched Dives	Average Discrepancy for Matched Dives	Number of Non-Matched Dives	Average Discrepancy for Non-Matched Dives	Difference of Average Discrepancies(DoAD)	p-value
BRU, Aristid (AUT)	6	0.21	207	-0.01	0.22	0.06
ROSLA, Rossharisham (MAS)	3	0.14	210	0.04	0.11	0.33
AXTELIU, Peter (SWE)	8	-0.04	205	-0.11	0.06	0.32
MIRZA KHANLAR, Gholamreza (IRI)	3	0.45	210	-0.09	0.54	0.09
SOROKIN, Anna (UKR)	12	0.26	201	0.01	0.25	0.01
BANUELO, Ricardo (MEX)	6	0.04	207	0.02	0.02	0.45
BOUSSAR, Michel (FRA)	10	0.09	203	0.04	0.05	0.31
BARBOS, Ana Virginia (BRA)	6	0.54	207	0.05	0.49	0.01
TOULOUDI, Nikolaos (GRE)	6	0.20	207	0.00	0.20	0.06
BEDDO, Valerie (AUS)	12	0.12	201	-0.01	0.13	0.08
SHOLTI, Christina (USA)	12	0.11	201	-0.03	0.14	0.19
STRITT BUR, Carmen (SUI)	6	-0.04	207	0.04	-0.08	0.64
IT, Masaaki (JPN)	12	0.32	201	0.00	0.32	0.00
MANZON, Renato (ITA)	12	0.10	201	-0.06	0.16	0.02
RUI, Rolando (CUB)	9	0.13	204	0.01	0.12	0.08
CALDERON RODRIGUE, Felix (PUR)	2	-0.18	211	0.04	-0.22	0.64
KELEME, Ildiko (HUN)	4	0.07	209	-0.03	0.10	0.29
TELLEFSE, Arne (NOR)	3	-0.02	210	-0.01	-0.01	0.56
DIETRIC, Monika (GER)	6	0.30	207	-0.03	0.32	0.02
BRAWLE, Nancy Jean (CAN)	10	0.23	203	-0.05	0.28	0.02
ANPIN, Cheng (CHN)	6	0.13	207	0.11	0.02	0.45
FABE, Marc (NED)	3	-0.21	210	-0.03	-0.19	0.75
VINOGRADO, Alexandr (RUS)	10	0.37	203	-0.07	0.44	0.01
RIOS HENA, Maria C. (COL)	6	0.24	207	0.03	0.20	0.14
CHONG HON KE, Kelvin (MAS)	6	0.42	207	-0.02	0.44	0.11
CHO, Ka Wah (HKG)	3	0.36	210	-0.13	0.49	0.02
TSU, Wing Hung (HKG)	3	-0.48	210	0.05	-0.53	0.76
ROCH, Sergio (MEX)	6	0.04	207	0.01	0.02	0.38
PACHEC, Caroline (PUR)	2	-0.14	211	0.09	-0.23	0.72
SAG, Christopher (GBR)	10	0.14	203	0.06	0.08	0.17
RA, Lang (CHN)	6	0.26	207	0.02	0.24	0.03
AL, Walter (GER)	4	0.13	209	0.09	0.04	0.42