Matlab TTL performance

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load required packages

Load all packages required for the analysis. If these packages are not available, install them on the fly with a `install.packages(<packagesname>)` call.

```
Pckglst = c("ezknitr", "ggplot2", "plyr", "knitr", "kableExtra")
for(cPckg in Pckglst){
    if(!require(cPckg , character.only=TRUE, warn.conflicts=F, quietly=T)){
        install.packages(cPckg)
        library(cPckg , character.only=TRUE, warn.conflicts=F, quietly=T)
    }
}
```

get data

helper functions

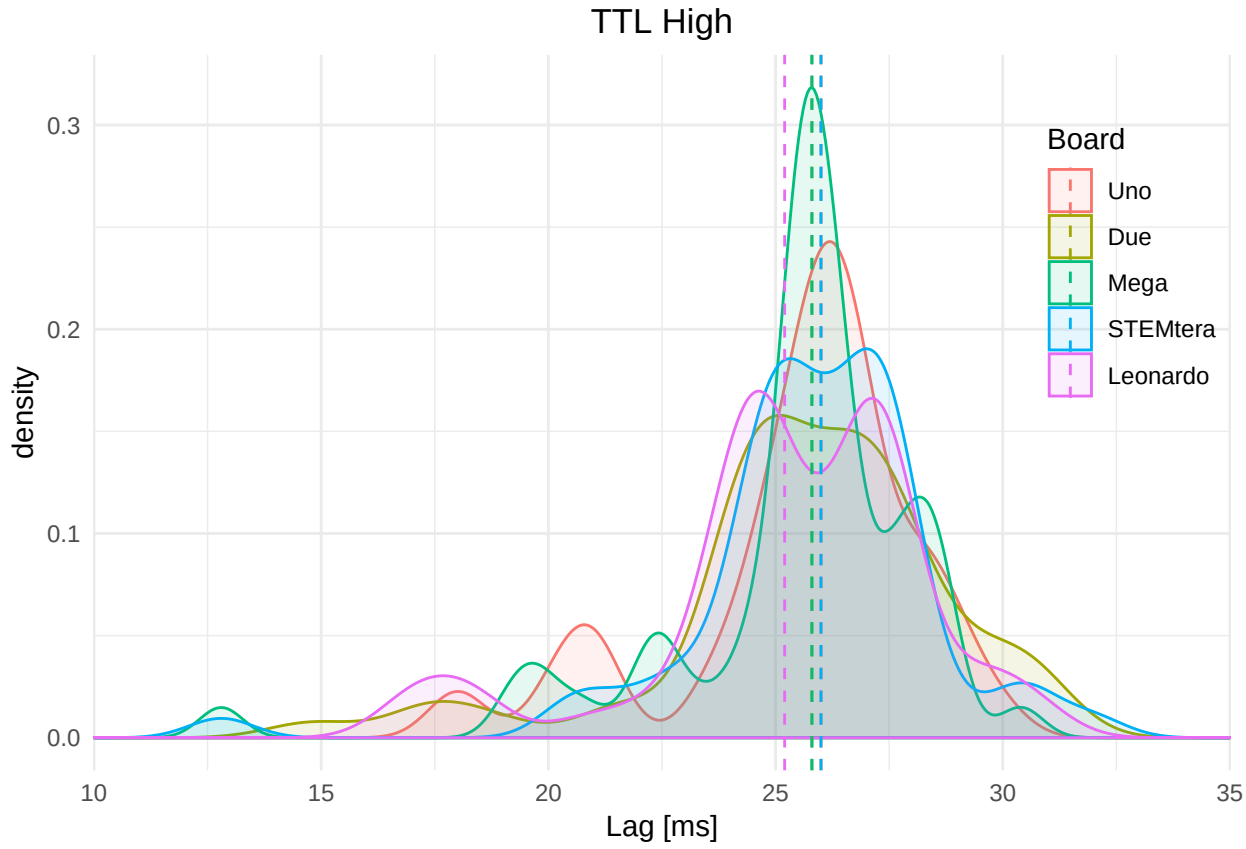
```
# read tektronix file
ReadTektronix = function(flnm=NA){
    dt = read.csv(flnm, header=FALSE, colClasses=c("NULL", "NULL", "NULL", NA, NA))

    tvec = as.numeric(dt$V4) * 1000
    vvec = as.numeric(dt$V5)

    na_pos = vvec < -8
    bvec = as.numeric(vvec > mean(vvec[!na_pos]))
    bvec[na_pos] = NA

    dvec = c(0, diff(bvec))

    pos = which(dvec != 0)

    On  = c()
    Off = c()

    for(p in 1:(length(pos)-1)){
        if(!any(is.na(dvec[pos[p]:pos[p+1]-1]))){
            itv = tvec[pos[p+1]-1] - tvec[pos[p]]
            if(dvec[pos[p]] ==  1){ On  = c(On,  itv)  }
            if(dvec[pos[p]] == -1){ Off = c(Off, itv)  }
        }
    }
    return(list(On=On, Off=Off))
}

# combine all files
```

```
ReadAllFiles = function(fllst=NA, BoardLbl=NA){

    for(i in 1:length(fllst)){
        tmpTTL = ReadTektronix(fllst[i])

        if(i==1){ TTL = tmpTTL }
        if(i!=1){ TTL = Map(c, TTL, tmpTTL) }
    }

    ITV   = c(TTL$On, TTL$Off)
    State = c(rep('ON', length(TTL$On)), rep('OFF', length(TTL$Off)))
    Board = rep(BoardLbl, length(State))

    return(data.frame(Board, State, ITV))
}
```

```
flset = 0:11

# Arduino Uno
fllst = sprintf('data/repeated_50on_50off/Arduino_uno/ALL%.4d/F%.4dCH1.CSV',
                flset, flset)
uno_df = ReadAllFiles(fllst, BoardLbl='Uno')

# Arduino Uno
fllst = sprintf('data/repeated_50on_50off/Arduino_due/ALL%.4d/F%.4dCH1.CSV',
                flset, flset)
due_df = ReadAllFiles(fllst, BoardLbl='Due')

# Sunfounder Mega
fllst = sprintf('data/repeated_50on_50off/Sunfounder_mega/ALL%.4d/F%.4dCH1.CSV',
                flset, flset)
mega_df = ReadAllFiles(fllst, BoardLbl='Mega')

# STEMtera
fllst = sprintf('data/repeated_50on_50off/STEMtera/ALL%.4d/F%.4dCH1.CSV',
                flset, flset)
STEM_df = ReadAllFiles(fllst, BoardLbl='STEMtera')

# Keystudio Leonardo
fllst = sprintf('data/repeated_50on_50off/keystudio_leonardo/ALL%.4d/F%.4dCH1.CSV',
                flset, flset)
leo_df = ReadAllFiles(fllst, BoardLbl='Leonardo')

# combine data
All_dt = rbind(uno_df, due_df)
All_dt = rbind(All_dt, mega_df)
All_dt = rbind(All_dt, STEM_df)
All_dt = rbind(All_dt, leo_df)

All_dt$ITV_diff = All_dt$ITV - 50

# split into ON and OFF periods
ON_dt  = droplevels(subset(All_dt, All_dt$State == 'ON'))
OFF_dt = droplevels(subset(All_dt, All_dt$State == 'OFF'))
```

High state time difference

```
mu <- ddply(ON_dt, "Board", summarise, grp.min=min(ITV_diff, na.rm=TRUE),
                                       grp.P25=quantile(ITV_diff, probs=0.25, na.rm=TRUE),
                                       grp.median=median(ITV_diff, na.rm=TRUE),
                                       grp.mean=mean(ITV_diff,     na.rm=TRUE),
                                       grp.P75=quantile(ITV_diff, probs=0.75, na.rm=TRUE),
                                       grp.max=max(ITV_diff,       na.rm=TRUE),
                                       grp.sd=sd(ITV_diff,         na.rm=TRUE),
                                       grp.iqr=IQR(ITV_diff,       na.rm=TRUE))

ggplot(ON_dt, aes(x=ITV_diff, color=Board, fill=Board))                                  +
    theme_minimal() + ggtitle('TTL High') + ylab('density') + xlab('Lag [ms]')          +
    theme(plot.title=element_text(hjust=0.5)) + theme(panel.border=element_blank())     +
    scale_x_continuous(limits=c(10, 35), expand=c(0, 0.01))                             +
    geom_density(aes(x=ITV_diff, fill=Board), alpha=0.1)                                +
    geom_vline(data=mu, aes(xintercept=grp.median, color=Board), linetype="dashed")     +
    theme(legend.justification=c(1, 0), legend.position=c(1, 0.5))
```



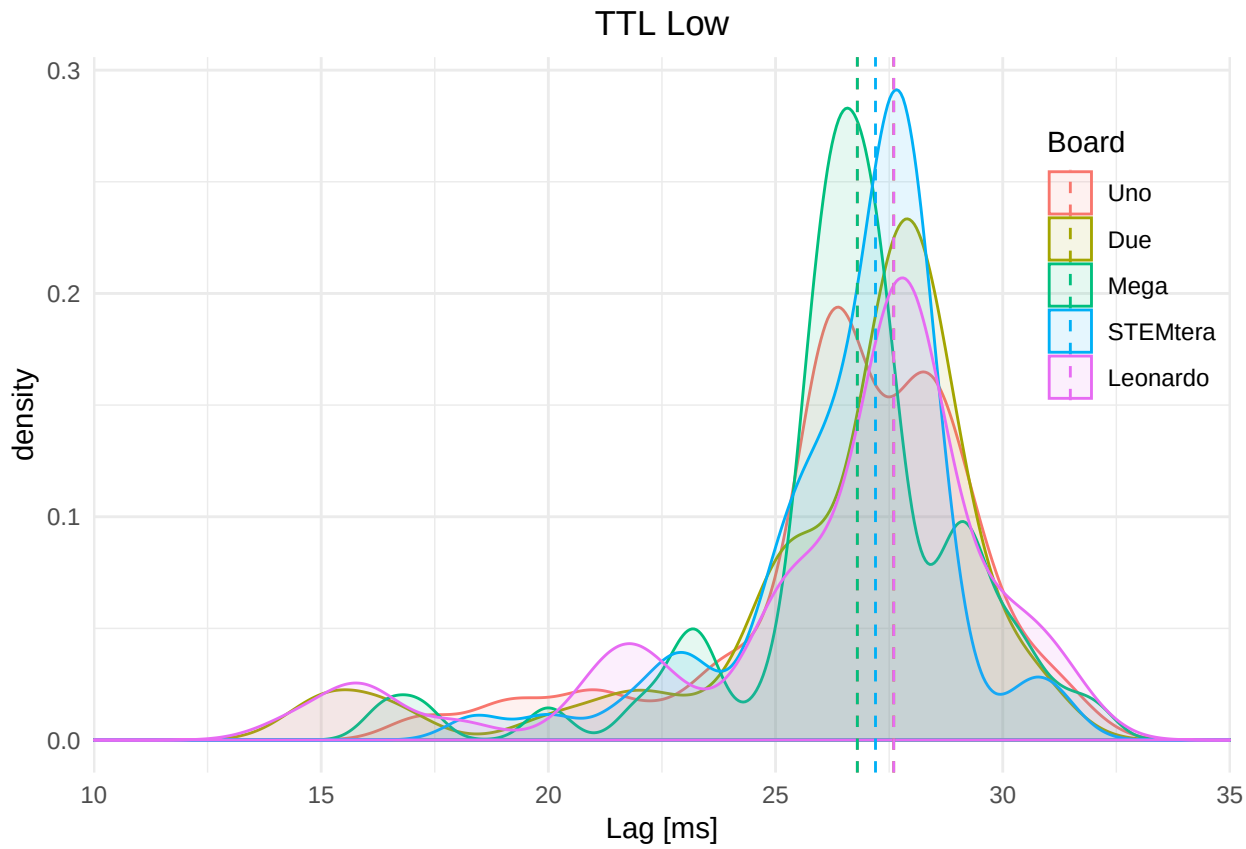

```
    #geom_histogram(aes(y=..density..), alpha=0.1, position="identity", binwidth=0.5) +

kable(mu, digits=2)  %>%
  kable_styling(latex_options = c("striped", "hover"), full_width=F)
```

Board	grp.min	grp.P25	grp.median	grp.mean	grp.P75	grp.max	grp.sd	grp.iqr
Uno	18.0	24.8	26.0	28.09	27.2	86.0	11.57	2.4
Due	14.8	24.4	25.8	25.64	27.6	30.8	3.18	3.2
Mega	12.8	25.2	25.8	25.41	26.8	30.4	2.87	1.6
STEMtera	12.8	24.8	26.0	25.82	27.2	32.0	2.79	2.4
Leonardo	16.8	24.4	25.2	25.28	27.2	30.8	3.03	2.8

```
ggsave('TTL_variability.png', width=8, height=6)
```

Low state time difference

```
mu <- ddply(OFF_dt, "Board", summarise, grp.min=min(ITV_diff, na.rm=TRUE),
                                        grp.P25=quantile(ITV_diff, probs=0.25, na.rm=TRUE),
                                        grp.median=median(ITV_diff, na.rm=TRUE),
                                        grp.mean=mean(ITV_diff,     na.rm=TRUE),
                                        grp.P75=quantile(ITV_diff, probs=0.75, na.rm=TRUE),
                                        grp.max=max(ITV_diff,       na.rm=TRUE),
                                        grp.sd=sd(ITV_diff,         na.rm=TRUE),
                                        grp.iqr=IQR(ITV_diff,       na.rm=TRUE))

ggplot(OFF_dt, aes(x=ITV_diff, color=Board, fill=Board))                              +
    theme_minimal() + ggtitle('TTL Low') + ylab('density') + xlab('Lag [ms]')        +
    theme(plot.title=element_text(hjust=0.5)) + theme(panel.border=element_blank())  +
    scale_x_continuous(limits=c(10, 35), expand=c(0, 0.01))                          +
    geom_density(aes(x=ITV_diff, fill=Board), alpha=0.1)                             +
    geom_vline(data=mu, aes(xintercept=grp.median, color=Board), linetype="dashed")  +
    theme(legend.justification=c(1, 0), legend.position=c(1, 0.5))
```




```
    # geom_histogram(aes(y=..density..), alpha=0.1, position="identity", binwidth=0.5) +

kable(mu, digits=2)  %>%
  kable_styling(latex_options = c("striped", "hover"), full_width=F)
```

Board	grp.min	grp.P25	grp.median	grp.mean	grp.P75	grp.max	grp.sd	grp.iqr
Uno	17.2	26.0	26.8	29.42	28.6	86.0	12.08	2.6
Due	14.8	25.4	27.6	26.31	28.2	30.8	3.60	2.8
Mega	16.4	26.0	26.8	26.53	27.6	32.0	2.85	1.6
STEMtera	9.2	25.6	27.2	26.35	28.0	31.2	3.20	2.4
Leonardo	14.4	25.2	27.6	26.13	28.0	31.6	3.94	2.8