EDN_ECP_summary

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1, Read in tables

```
rm(list=ls())  # clean up workspace
path <- "/Users/xji3/GitFolders/EDN_ECP/Summary/MG94"

summary.list <- c("_clock_summary",
                  "_nonclock_summary",
                  "_Force_clock_summary",
                  "_Force_nonclock_summary"
                  )
pair = c("EDN", "ECP")
for (target.summary in summary.list){
  summary_file <- paste(path, "_EDN_ECP", target.summary, '.txt', sep = '')
  all <- readLines(summary_file, n = -1)
  row.names <- strsplit(all[length(all)], ' ')[[1]][-1]
  col.name <- paste("MG94", target.summary, sep = "")
  summary_mat <- as.matrix(read.table(summary_file,
                                      row.names = row.names,
                                      col.names = col.name))
  assign(paste("MG94", target.summary, sep = ""), summary_mat)
}
ECP.EDN.MG94 <- cbind(MG94_nonclock_summary, MG94_clock_summary,
                      MG94_Force_nonclock_summary, MG94_Force_clock_summary)
ECP.EDN.MG94
```

```
##                       MG94_nonclock_summary MG94_clock_summary
## length                         1.570000e+02       1.570000e+02
## ll                            -1.700519e+03      -1.703650e+03
## pi_a                           2.910093e-01       2.916945e-01
## pi_c                           2.433912e-01       2.426929e-01
## pi_g                           2.069226e-01       2.068703e-01
## pi_t                           2.586769e-01       2.587424e-01
## kappa                          2.062436e+00       2.089065e+00
## omega                          8.270292e-01       8.389169e-01
## tau                            6.312271e-01       6.207583e-01
## (N0,N1)                        1.990860e-01       1.960748e-01
## (N0,Tamarin)                   3.252961e-01       3.268887e-01
## (N1,N2)                        3.193865e-02       5.181832e-02
## (N1,Macaque)                   1.564817e-01       1.250430e-01
## (N2,N3)                        3.455331e-02       5.565978e-02
## (N2,Orangutan)                 8.979048e-02       7.322467e-02
## (N3,Chimpanzee)                1.427697e-02       1.756489e-02
## (N3,Gorilla)                   1.596838e-02       1.756489e-02
## (N0,N1,tau)                    5.202655e-01       5.194297e-01
## (N0,Tamarin,tau)               0.000000e+00       0.000000e+00
## (N1,N2,tau)                    4.162337e-01       4.911286e-01
## (N1,Macaque,tau)               3.747596e-01       3.373610e-01
## (N2,N3,tau)                    4.485431e-01       4.106192e-01
```

```
## (N2,Orangutan,tau)            1.071400e+00       1.231183e+00
## (N3,Chimpanzee,tau)           4.868393e-02       6.296886e-02
## (N3,Gorilla,tau)              4.722111e-01       4.331299e-01
## (N0,N1,1->2)                  2.592440e+00       2.515012e+00
## (N0,Tamarin,1->2)             0.000000e+00       0.000000e+00
## (N1,N2,1->2)                  3.635547e-01       7.182819e-01
## (N1,Macaque,1->2)             1.512961e+00       1.002534e+00
## (N2,N3,1->2)                  5.827584e-01       8.879946e-01
## (N2,Orangutan,1->2)           6.399548e+00       6.069097e+00
## (N3,Chimpanzee,1->2)          6.505905e-02       1.065007e-01
## (N3,Gorilla,1->2)             5.130258e-02       6.176839e-02
## (N0,N1,2->1)                  2.592440e+00       2.515012e+00
## (N0,Tamarin,2->1)             0.000000e+00       0.000000e+00
## (N1,N2,2->1)                  9.049477e-01       1.701750e+00
## (N1,Macaque,2->1)             5.101368e+00       3.726697e+00
## (N2,N3,2->1)                  1.046395e+00       1.519445e+00
## (N2,Orangutan,2->1)           3.413858e+00       3.137466e+00
## (N3,Chimpanzee,2->1)          1.286481e-02       1.756355e-02
## (N3,Gorilla,2->1)             7.941026e-01       7.916351e-01
## (N0,N1,mut)                   6.295535e+01       6.198371e+01
## (N0,Tamarin,mut)              5.115805e+01       5.141753e+01
## (N1,N2,mut)                   1.045748e+01       1.399356e+01
## (N1,Macaque,mut)              5.231267e+01       4.851329e+01
## (N2,N3,mut)                   1.122474e+01       1.245078e+01
## (N2,Orangutan,mut)            2.350807e+01       2.198678e+01
## (N3,Chimpanzee,mut)           5.280903e+00       5.203542e+00
## (N3,Gorilla,mut)              5.147585e+00       5.162176e+00
##                      MG94_Force_nonclock_summary MG94_Force_clock_summary
## length                             1.570000e+02            1.570000e+02
## ll                                -1.714099e+03           -1.716567e+03
## pi_a                               2.927431e-01            2.927869e-01
## pi_c                               2.425981e-01            2.421026e-01
## pi_g                               2.076225e-01            2.078204e-01
## pi_t                               2.570363e-01            2.572901e-01
## kappa                              2.100482e+00            2.102322e+00
## omega                              9.044276e-01            9.065773e-01
## tau                                0.000000e+00            0.000000e+00
## (N0,N1)                            1.440343e-01            1.400382e-01
## (N0,Tamarin)                       3.556100e-01            3.579323e-01
## (N1,N2)                            4.519787e-02            6.042200e-02
## (N1,Macaque)                       1.777791e-01            1.480029e-01
## (N2,N3)                            4.510421e-02            6.707861e-02
## (N2,Orangutan)                     9.981750e-02            8.758086e-02
## (N3,Chimpanzee)                    1.699996e-02            2.050224e-02
## (N3,Gorilla)                       1.880088e-02            2.050224e-02
## (N0,N1,tau)                        0.000000e+00            0.000000e+00
## (N0,Tamarin,tau)                   0.000000e+00            0.000000e+00
## (N1,N2,tau)                        0.000000e+00            0.000000e+00
## (N1,Macaque,tau)                   0.000000e+00            0.000000e+00
## (N2,N3,tau)                        0.000000e+00            0.000000e+00
## (N2,Orangutan,tau)                 0.000000e+00            0.000000e+00
## (N3,Chimpanzee,tau)                0.000000e+00            0.000000e+00
## (N3,Gorilla,tau)                   0.000000e+00            0.000000e+00
## (N0,N1,1->2)                       0.000000e+00            0.000000e+00
```

```
## (N0,Tamarin,1->2)                  0.000000e+00            0.000000e+00
## (N1,N2,1->2)                       0.000000e+00            0.000000e+00
## (N1,Macaque,1->2)                  0.000000e+00            0.000000e+00
## (N2,N3,1->2)                       0.000000e+00            0.000000e+00
## (N2,Orangutan,1->2)                0.000000e+00            0.000000e+00
## (N3,Chimpanzee,1->2)               0.000000e+00            0.000000e+00
## (N3,Gorilla,1->2)                  0.000000e+00            0.000000e+00
## (N0,N1,2->1)                       0.000000e+00            0.000000e+00
## (N0,Tamarin,2->1)                  0.000000e+00            0.000000e+00
## (N1,N2,2->1)                       0.000000e+00            0.000000e+00
## (N1,Macaque,2->1)                  0.000000e+00            0.000000e+00
## (N2,N3,2->1)                       0.000000e+00            0.000000e+00
## (N2,Orangutan,2->1)                0.000000e+00            0.000000e+00
## (N3,Chimpanzee,2->1)               0.000000e+00            0.000000e+00
## (N3,Gorilla,2->1)                  0.000000e+00            0.000000e+00
## (N0,N1,mut)                        4.544445e+01            4.418651e+01
## (N0,Tamarin,mut)                   5.598401e+01            5.635691e+01
## (N1,N2,mut)                        1.427259e+01            1.584501e+01
## (N1,Macaque,mut)                   5.608860e+01            5.462142e+01
## (N2,N3,mut)                        1.422474e+01            1.573075e+01
## (N2,Orangutan,mut)                 3.153865e+01            3.006394e+01
## (N3,Chimpanzee,mut)                5.352806e+00            5.299775e+00
## (N3,Gorilla,mut)                   5.923543e+00            5.952135e+00
```

2, Now show branch specific % changes due to IGC

```
(ECP.EDN.MG94[26:33, ] + ECP.EDN.MG94[34:41, ])/(ECP.EDN.MG94[42:49, ] + ECP.EDN.MG94[26:33, ] + ECP.EDN
```

```
##                      MG94_nonclock_summary MG94_clock_summary
## (N0,N1,1->2)                    0.07609132         0.07505960
## (N0,Tamarin,1->2)               0.00000000         0.00000000
## (N1,N2,1->2)                    0.10817880         0.14744073
## (N1,Macaque,1->2)               0.11224614         0.08882434
## (N2,N3,1->2)                    0.12674399         0.16202747
## (N2,Orangutan,1->2)             0.29450698         0.29514515
## (N3,Chimpanzee,1->2)            0.01454122         0.02328706
## (N3,Gorilla,1->2)               0.14106566         0.14186554
##                      MG94_Force_nonclock_summary MG94_Force_clock_summary
## (N0,N1,1->2)                                   0                         0
## (N0,Tamarin,1->2)                              0                         0
## (N1,N2,1->2)                                   0                         0
## (N1,Macaque,1->2)                              0                         0
## (N2,N3,1->2)                                   0                         0
## (N2,Orangutan,1->2)                            0                         0
## (N3,Chimpanzee,1->2)                           0                         0
## (N3,Gorilla,1->2)                              0                         0
```

3, % changes due to IGC in all branches

```
colSums(ECP.EDN.MG94[26:33, ] + ECP.EDN.MG94[34:41, ])/colSums(ECP.EDN.MG94[42:49, ] + ECP.EDN.MG94[26:3
```

```
##       MG94_nonclock_summary          MG94_clock_summary
##                   0.1027710                   0.1009066
## MG94_Force_nonclock_summary    MG94_Force_clock_summary
##                   0.0000000                   0.0000000
```

04212017 update

Now plot posterior log likelihood ratio: $ln(\frac{Pr(S_i=1|x)}{Pr(S_i=0|x)}$.

The derivatives are $\frac{\partial \ln L}{\partial \ln p_{tract}}$ for the first order and $\frac{\partial^2 \ln L}{\partial \ln {p_{tract}}^2}$ for second order.

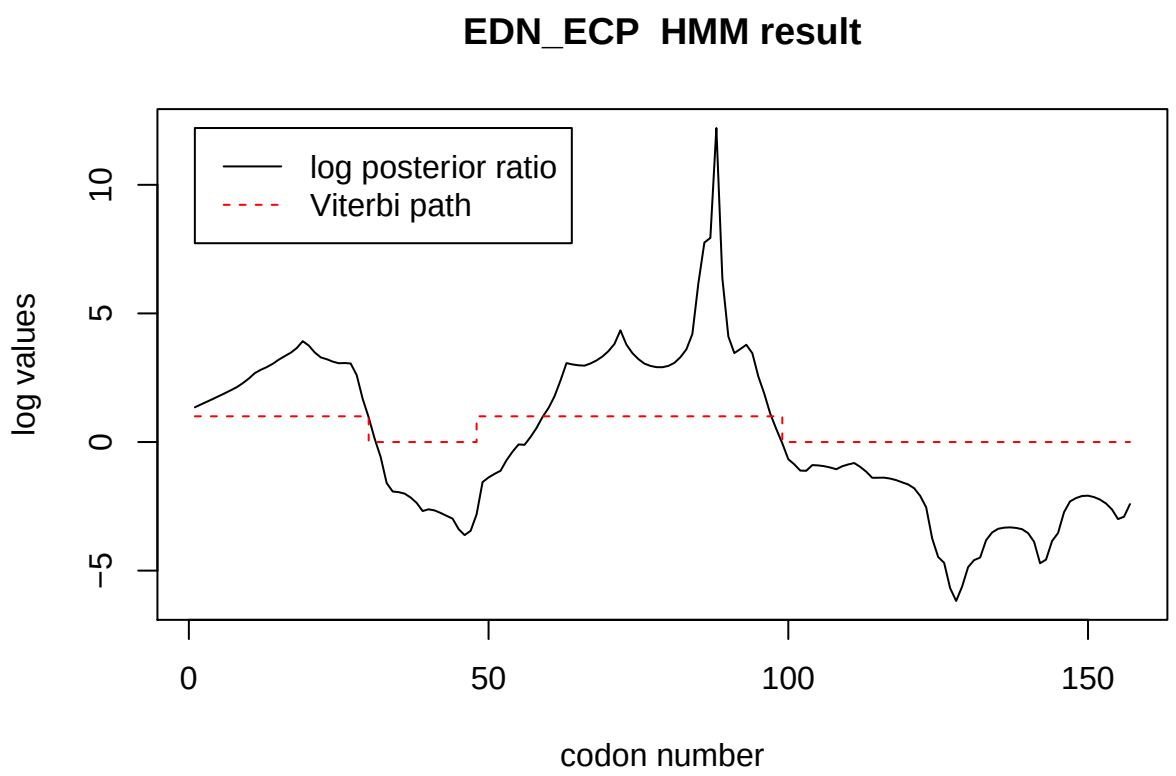
The variance is calculated by: $Var(ln(p_{tract})) = \frac{1}{I(ln(p_{tract}))} \approx -\frac{1}{\frac{\partial^2 \ln L}{\partial \ln {p_{tract}}^2}}$

95% confidence interval for $ln(p_{tract})$ is $ln(p_{tract}) \pm 1.96 * \sqrt{Var(\ln(p_{tract}))}$

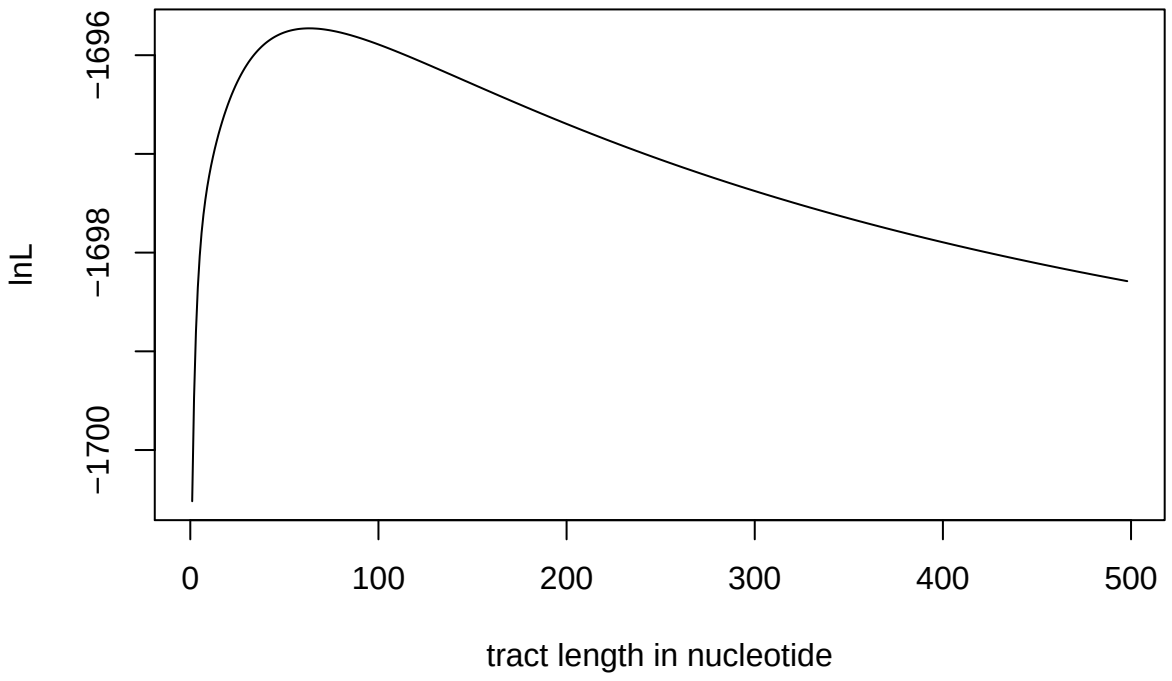
By transforming to $3.0/p_{tract}$ to get the average tract length in nucleotide.

```
# plot one paralog
paralog = "EDN_ECP"
lnL.ratio <- as.vector(read.table(paste("./summary/", paralog, "_MG94_nonclock_HMM_log_posterior_ratio.t
Viterbi.path <- as.vector(read.table(paste("./summary/", paralog, "_MG94_nonclock_HMM_Viterbi_path.txt"
lnL.surface <- as.vector(read.table(paste("./summary/", paralog, "_MG94_nonclock_HMM_lnL_surface.txt", s
IGC.sw.lnL <- as.vector(read.table(paste("./summary/", paralog, "_MG94_nonclock_sw_lnL.txt", sep = ""))
Force.sw.lnL <- as.vector(read.table(paste("./summary/Force_", paralog, "_MG94_nonclock_sw_lnL.txt", sep

plot(lnL.ratio[, 1], xlab = "codon number", ylab = "log values",
     type = "l", col = "black", lty = 1,
     main = paste(paralog, " HMM result"),
     ylim = c(min(-0.5, min(lnL.ratio)), max(lnL.ratio)))
lines(1:dim(Viterbi.path)[1], Viterbi.path[, 1], type = "S", lty = 2, col = "red")
#lines(1:dim(IGC.sw.lnL)[1], IGC.sw.lnL[, 2] - Force.sw.lnL[, 2], type = "l", lty = 3, col = "red")
legend(1, max(lnL.ratio), legend = c("log posterior ratio", "Viterbi path"),
       lty = c(1, 2), col = c( "black", "red"))
```




```
plot(-lnL.surface[, 1], xlab = "tract length in nucleotide", ylab= "lnL", type = "l", col = "black", lty
     main = paste(paralog, " lnL surface"))
```




```
summary.mat <- read.table("./HMM_tract_MG94_nonclock_summary.txt")

# Now calculate standard deviation of lnP
lnP <- log(3.0 / summary.mat[, 3])
sd.lnP <- 1.0 / sqrt(-summary.mat[, 7])
low.cf <- exp(lnP - 1.96 * sd.lnP)
up.cf  <- exp(lnP + 1.96 * sd.lnP)
up.cf[up.cf > 1] <- 1.0
summary.mat <- cbind(summary.mat, 3.0 / up.cf, 3.0 / low.cf)
rownames(summary.mat) <- c("EDN_ECP")
colnames(summary.mat) <- c("lnL", "max lnL", "tract length",
                           "Pr(S_0)", "Pr(S_1)",
                           "df", "d^2f", "c.i. tract length", "c.i tract length")
summary.mat
```

```
##               lnL   max lnL tract length   Pr(S_0)   Pr(S_1)           df
## EDN_ECP -1700.519 -1695.728     65.48743 0.5043814 0.4956186 4.592165e-06
##              d^2f c.i. tract length c.i tract length
## EDN_ECP -1.631126          14.11443         303.8453
```

09132017 update

Now plot lnL surface of MG94+IS-IGC+HMM model.

The derivatives are $\frac{\partial \ln L}{\partial \ln p_{tract}}$ for the first order and $\frac{\partial^2 \ln L}{\partial \ln {p_{tract}}^2}$ for second order.

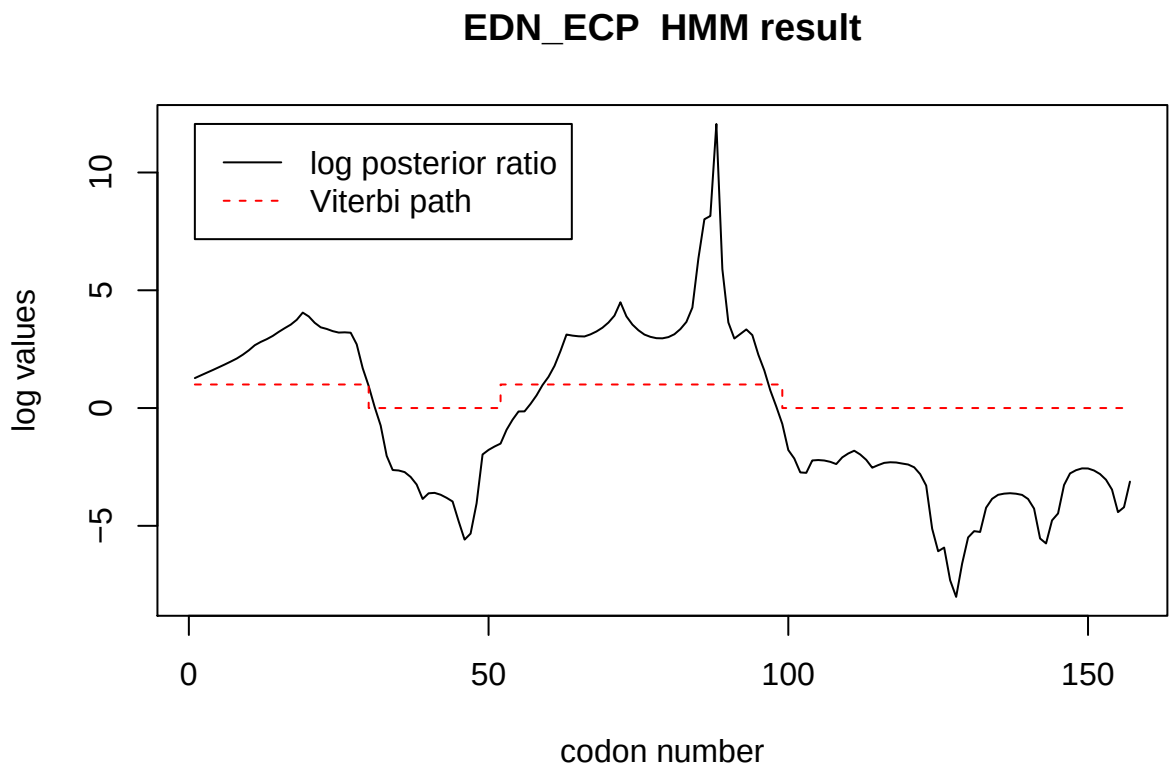
The variance is calculated by: $Var(ln(p_{tract})) = \frac{1}{I(ln(p_{tract}))} \approx -\frac{1}{\frac{\partial^2 \ln L}{\partial \ln {p_{tract}}^2}}$

95% confidence interval for $ln(p_{tract})$ is $ln(p_{tract}) \pm 1.96 * \sqrt{Var(\ln(p_{tract}))}$

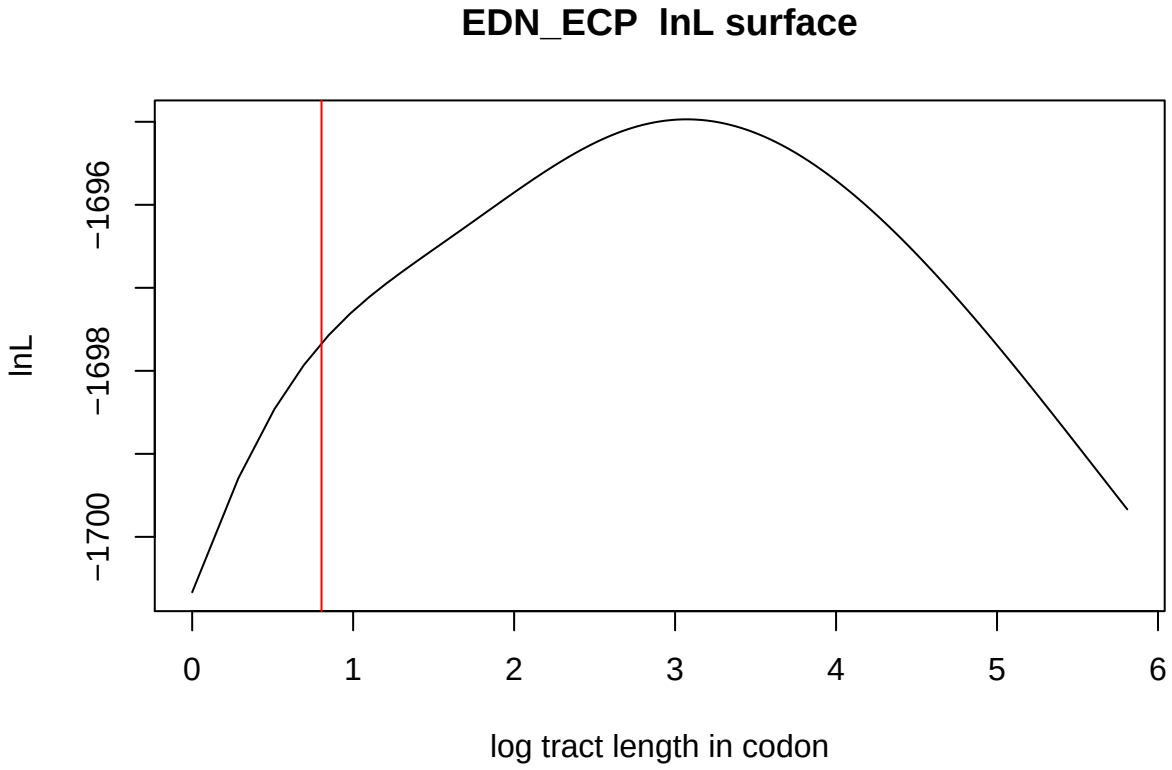
By transforming to $3.0/p_{tract}$ to get the average tract length in nucleotide.

```
# plot one paralog
paralog = "EDN_ECP"
lnL.ratio <- as.vector(read.table(paste("./summary/", paralog, "_Ind_MG94_HMM_Posterior_lnL.txt", sep =
Viterbi.path <- as.vector(read.table(paste("./summary/", paralog, "_Ind_MG94_HMM_Viterbi_array.txt", se
lnL.surface <- as.vector(read.table(paste("./plot/HMM_", paralog, "_lnL_1D_surface.txt", sep = "")))

plot(1:dim(lnL.ratio)[1], lnL.ratio[, 2] - lnL.ratio[, 1], xlab = "codon number", ylab = "log values",
     type = "l", col = "black", lty = 1,
     main = paste(paralog, " HMM result"),
     ylim = c(min(-0.5, min(lnL.ratio[, 2] - lnL.ratio[, 1])), max(lnL.ratio[, 2] - lnL.ratio[, 1])))
lines(1:dim(Viterbi.path)[1], Viterbi.path[, 1], type = "S", lty = 2, col = "red")
legend(1, max(lnL.ratio[, 2] - lnL.ratio[, 1]), legend = c("log posterior ratio", "Viterbi path"),
       lty = c(1, 2), col = c( "black", "red"))
```




```
plot.new()
plot(-lnL.surface[, 1],lnL.surface[, 2], xlab = "log tract length in codon", ylab= "lnL", type = "l", c
     main = paste(paralog, " lnL surface"))
abline(v = log(6.7/3.), col = "red")
```




```
summary.mat <- read.table("./Summary/EDN_ECP_Ind_MG94_HMM_1D_summary.txt")
hessian <- read.table("./Summary/EDN_ECP_Ind_MG94_HMM_Hessian.txt")

# Now calculate standard deviation of lnP
lnP <- log(summary.mat[10,1])
sd.lnP <- 1.0 / sqrt(-hessian[2, 1])
low.cf <- exp(lnP - 1.96 * sd.lnP)
up.cf  <- exp(lnP + 1.96 * sd.lnP)
up.cf[up.cf > 1] <- 1.0
show.mat <- matrix(c(summary.mat[1,1], max(-lnL.surface[, 2]), 3.0/summary.mat[10, 1],
              hessian[1,1], hessian[2,1], 3.0 / up.cf, 3.0 / low.cf), 1, 7)
rownames(show.mat) <- c("EDN_ECP")
colnames(show.mat) <- c("lnL", "max lnL", "tract length",
                        "df", "d^2f", "c.i. tract length", "c.i tract length")
show.mat
```

```
##             lnL  max lnL tract length         df      d^2f
## EDN_ECP 1694.97 1700.667     64.75272 1.7338e-05 -1.825787
##         c.i. tract length c.i tract length
## EDN_ECP           15.1808         276.1986
```