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# Step-by-step illustration of Metropolis sampling for a 1D posterior


# Function to compute the posterior distribution:
# Likelihood: Y[i] ~ Bern(expit(theta))
# Prior:      theta ~ Normal(pri_mn,pri_sd)
post <- function(theta,Y,pri_mn=0,pri_sd=1){
   prob  <- exp(theta)/(1+exp(theta))
   prior <- dnorm(theta,pri_mn,pri_sd)
   like  <- prod(dbinom(Y,1,prob))
return(like*prior)}


# Generate fake data

 set.seed(0820)
 Y<-rbinom(20,1,0.7)

# Compute the posterior on a grid for reference

 theta_grid <- seq(-3,3,length=100)
 dense      <- rep(0,100)
 for(i in 1:100){
   dense[i]<-post(theta_grid[i],Y)
 }


# MCMC set-up

  n.iters <- 10000
  can_sd  <- 0.5 # Try different values of can_sd to see the effect on the acceptance rate


#initial value

  theta      <- 0
  keep_theta <- rep(0,n.iters)

# Go!

  par(ask=TRUE,mfrow=c(1,1))
  for(iter in 1:n.iters){

    # Draw a candidate and compute acceptance ratio:

     can <- rnorm(1,theta,can_sd)
     p1  <- post(can,Y)
     p2  <- post(theta,Y)
     R   <- p1/p2
     R   <- ifelse(R>1,1,R)

    # Plot the candidate:

     if(iter<50){

      plot(theta_grid,dense,type="l",lwd=2,
           xlab=expression(theta),ylab=expression(paste("f",theta,"|Y)")))
      lines(c(theta,theta),c(0,p2),col=2,lwd=2)
      lines(rep(can,2),c(0,p1),col=3,lwd=2)

      leg    <- NULL
      leg[1] <- paste("R = ",round(R,2))
      leg[2] <- paste("Old value = ",round(theta,2))
      leg[3] <- paste("Candidate = ",round(can,2))

      legend("topleft",leg,lty=1,col=1:3,inset=0.05)
     }

    # Make a decision:

     keep     <- rbinom(1,1,R)==1
     if(keep){
        theta<-can
     }
     keep_theta[iter]<-theta
  }

# Plot the results:

  par(ask=FALSE,mfrow=c(2,2))
  plot(keep_theta,type="l",xlab="MCMC Iteration",ylab=expression(theta),main="Trace plot")
  acf(keep_theta)
  hist(keep_theta,breaks=50,main="Posterior of theta")
  keep_p <- exp(keep_theta)/(1+exp(keep_theta))
  hist(keep_p,breaks=50,main="Posterior of p")
```