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% gda02_15
%
% create realizations of an exponential p.d.f. in two ways,
% transformation of a uniform distribution, and the Metropolis
% algoritm.  In this example, the p.d.f. is
% p(d) = c*exp(-d)/c); for d>0
%
% supports Figure 2.17

clear all;

% d-axis
dmin = -10;
dmax = 10;
N = 201;
Dd = (dmax-dmin)/(N-1);
d = dmin + Dd*[0:N-1]';

% evaluate exponential distribution
c = 2.0;
pexp = (0.5/c)*exp(-abs(d)/c);

% the usual transformation rule is p(d) = p(m(d)) |dm/dd|
% suppose that p(m) is uniform over m=(-1,1) with amplitude 0.5
% handle the absolute value sign by breaking into two parts,
% Part 1: m>0,
%     (1/c)*exp(-d/c)=(+/-)dm/dd.  Choose the + sign, in order
%     to map m=0 with d=0 and m=1 to d=infinity.  Then
%     m =(integral)(1/c)*exp(-d/c)dd+constant.  Choose constant=1
%     so m=1-exp(-d/c). Inverting gives d=-c*ln((1-m))
% Part 2: m<0
%     similar calculation gives d=-c*ln((1+m))
%     so overall d=-sgn(m)*c*ln((1-abs(m)))

% transform realizations of a uniform distribution to p(d)
M=5000;
rm=random('Uniform',-1,1,M,1);
rd=-sign(rm).*c.*log((1-abs(rm)));

% histogram
Nb=26;
Db=(dmax-dmin)/(Nb-1);
bins=dmin+Db*[0:Nb-1]';
h = hist(rd,bins)';

% convert histogram to a p.d.f.
norm=Db*sum(h);
h=h/norm;

figure(1);
set(gcf,'pos',[10, 10, 600, 250]);
clf;

% plot histogram of transformed realizations and true pdf
subplot(1,2,1);
set(gca,'LineWidth',3);
set(gca,'FontSize',14);
hold on;
axis( [dmin, dmax, 0, 0.3 ] );
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% improvise bar chart
for i = [1:Nb-1]
    tb = [bins(i)-Db/2, bins(i)-Db/2, bins(i)+Db/2, bins(i)+Db/2]';
    th = [0, h(i), h(i), 0]';
    plot(tb,th,'b-','LineWidth',3);
end
plot(d,pexp,'r-','LineWidth',3);
xlabel('d');
ylabel('p(d)');

% Metropolis
Niter=5000;
rd  = zeros(Niter,1);
prd = zeros(Niter,1);
rd(1)  = 0.0;
prd(1) = (1/c)*exp(-abs(rd(1))/c);
s = 1;

for k = [2:Niter]
    % old realization
    rdo = rd(k-1);
    prdo = prd(k-1);
    rdn = random('Normal',rdo,s);
    prdn = (0.5/c)*exp(-abs(rdn)/c);
    % test parameter, ratio of probabilities
    a = prdn/prdo;
    % acceptance test
    if( a>1 )
        rd(k) = rdn;
        prd(k) = prdn;
    else
        r = random('Uniform',0,1);
        if( a>r )
            rd(k) = rdn;
            prd(k) = prdn;
        else
            rd(k) = rdo;
            prd(k) = prdo;
        end
    end
end

% histogram, converted to a p.d.f.
h = hist(rd,bins)';
norm=Db*sum(h);
h=h/norm;

% plot histogram of transformed realizations and true pdf
subplot(1,2,2);
set(gca,'LineWidth',3);
set(gca,'FontSize',14);
hold on;
axis( [dmin, dmax, 0, 0.3 ] );
% improvise bar chart
for i = [1:Nb-1]
    tb = [bins(i)-Db/2, bins(i)-Db/2, bins(i)+Db/2, bins(i)+Db/2]';
    th = [0, h(i), h(i), 0]';
    plot(tb,th,'b-','LineWidth',3);
end
plot(d,pexp,'r-','LineWidth',3);
xlabel('d');
```

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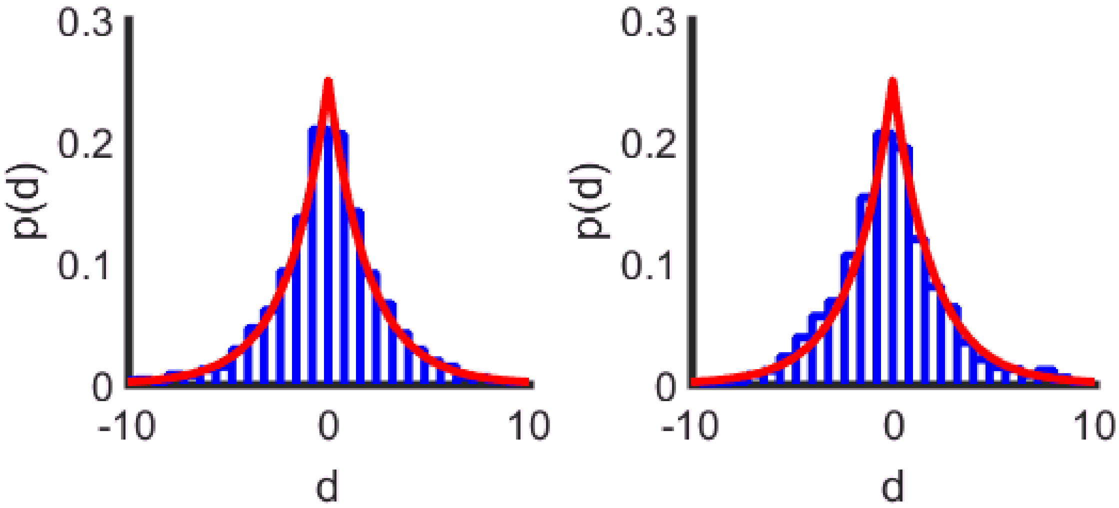
ylabel('p(d)');
```

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% Figure 2.17 Histograms (blue curves) of 5000 realizations of a random variable d for
% the probability density function (red curves) p(d) = &frac12;cexp(-|d|/c) with c = 2.
% (A) Realizations computed by transforming data drawn from a uniform distribution and
% (B) realizations computed using the Metropolis-Hastings algorithm. MatLab script gda02_15.
```