**ECE 3800:** PROGRAMMING PROJECT #3

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% ECE 3800: Programming Project #3

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function blackjack(N)

clf

shg

set(gcf,'name','Blackjack','menu','none','numbertitle','off', ...

'userdata',[])

rand('state',sum(100\*clock))

if nargin == 0

N = 20000;

kase = 1;

else

if ischar(N)

N = str2double(N);

end

bj(N)

kase = 2;

end

while kase > 0

kase = bjbuttonclick(kase);

switch kase

case 0, break % Close

case 1, bj(1) % Play one hand

case 2, bj(N) % Simulate

end

end

close(gcf)

% ------------------------

function bj(N)

% Blackjack, main program that plays N number of hands, and for our simulation we let N = 20000.

% If N == 1, show detail and allow interaction.

S = get(gcf,'userdata');

n = length(S);

bet = 10;

detail = N==1;

% graphics

if detail

delete(get(gca,'children'))

delete(findobj(gcf,'type','axes'))

axes('pos',[0 0 1 1])

axis([-5 5 -5 5])

axis off

bjbuttons('detail');

stake = sum(S);

if stake >= 0, sig = '+'; else, sig = '-'; end

str = sprintf('%6.0f hands, $ %c%d',n,sig,abs(stake));

titl = text(-2.5,4.5,str,'fontsize',20);

n0 = n+1;

n1 = n0;

else

bjbuttons('off');

payoffs = [-4:1 1.5 2:4]\*bet; % Possible payoffs

counts = hist(S,payoffs);

n0 = n+1;

n1 = ceil((n0)/N)\*N;

subplot(2,1,2)

h = plot(0,0);

end

S = [S zeros(1,n1-n0+1)];

for n = n0:n1

bet1 = bet;

P = deal; % player's hand

D = deal; % Dealer's hand

P = [P deal];

D = [D -deal]; % Hide dealer's hole card

% Split twoOfaKinds

split = mod(P(1),13)==mod(P(2),13);

if split

if detail

show('Player',P)

show('Dealer',D)

split = twoOfaKind(value(P(1)),value(D(1)));

% 0 = Keep twoOfaKind

% 1 = Split twoOfaKind

split = bjbuttonclick('split',split+1);

else

split = twoOfaKind(value(P(1)),value(D(1)));

end

end

if split

P2 = P(2);

if detail, show('Split',P2); end

P = [P(1) deal];

bet2 = bet1;

end

% Play player's hand(s)

if detail

[P,bet1] = playhand('Player',P,D,bet1);

show('Player',P)

if split

P2 = [P2 deal];

show('Split',P2)

[P2,bet2] = playhand('Split',P2,D,bet2);

end

else

[P,bet1] = playhand('',P,D,bet1);

if split

P2 = [P2 deal];

[P2,bet2] = playhand('',P2,D,bet2);

end

end

% Play dealer's hand

D(2) = -D(2); % Reveal dealer's hole card

while value(D) <= 16

D = [D deal];

end

% Payoff

if detail

show('Dealer',D)

show('Player',P)

s = payoff('Player',P,D,split,bet1);

if split

show('Split',P2)

s = s + payoff('Split',P2,D,split,bet2);

end

else

s = payoff('',P,D,split,bet1);

if split

s = s + payoff('',P2,D,split,bet2);

end

end

S(n) = s;

if detail

stake = stake + s;

if stake >= 0, sig = '+'; else, sig = '-'; end

str = sprintf('%6.0f hands, $ %c%d',n,sig,abs(stake));

set(titl,'string',str)

end

chunk = min(2000,N);

if ~detail & mod(n,chunk) == 0

Schunk = S(n-chunk+1:n);

subplot(2,1,2)

ydata = get(h,'ydata');

ydata = ydata(end) + cumsum(Schunk);

ylim = get(gca,'ylim');

if max(ydata) > ylim(1) | min(ydata) < ylim(2)

ydata = cumsum(S(1:n));

h = plot(1:n,ydata);

line([1 n1],[0 0],'color','black')

ylim = 1000\*[floor(min(min(ydata)/1000,-1)) ...

ceil(max(max(ydata)/1000,1))];

axis([1 n1 ylim])

else

set(h,'xdata',n-chunk+1:n,'ydata',ydata);

end

subplot(2,1,1)

[kounts,x] = hist(S(n-chunk+1:n),payoffs);

counts = counts + kounts;

p = counts/n;

bar(x,p)

axis([-4.5\*bet 4.5\*bet 0 .45])

stake = ydata(end);

if stake >= 0, sig = '+'; else, sig = '-'; end

str = sprintf('%c%d',sig,abs(stake));

if abs(stake) < 1000, str = [' ' str]; end

if abs(stake) < 100, str = [' ' str]; end

if abs(stake) < 10, str = [' ' str]; end

title(sprintf('%6.0f hands, $ %s',n,str))

set(gca,'xtick',payoffs);

for k = 1:length(payoffs)

if payoffs(k)==15, y = -.12; else, y = -.08; end

text(payoffs(k)-6.5,y,sprintf('%9.4f',p(k)));

end

% Mean and confidence interval, relative to unit bet

r = payoffs/bet;

mu = p\*r';

crit = 1.96; % norminv(.975)

rho = crit\*sqrt((p\*(r.^2)'-mu^2)/n);

pm = char(177);

text(20,.3,sprintf('%6.4f %c %6.4f',mu,pm,rho));

drawnow

end

end

set(gcf,'userdata',S);

% ------------------------

function c = deal

% Deal one card

persistent deck ncards

if isempty(deck) | ncards < 6

% Four decks

deck = [1:52 1:52 1:52 1:52];

% Shuffle

ncards = length(deck);

deck = deck(randperm(ncards));

end

c = deck(ncards);

ncards = ncards - 1;

% ------------------------

function v = valuehard(X)

% Evaluate hand

X = mod(X-1,13)+1;

X = min(X,10);

v = sum(X);

% ------------------------

function v = value(X)

% Evaluate hand

X = mod(X-1,13)+1;

X = min(X,10);

v = sum(X);

% Promote soft ace

if any(X==1) & v<=11

v = v + 10;

end

% ------------------------

function [P,bet] = playhand(hand,P,D,bet)

% Play player's hand

while value(P) < 21

% 0 = stand

% 1 = hit

% 2 = double down

if any(mod(P,13)==1) & valuehard(P)<=10

strat = soft(value(P)-11,value(D(1)));

else

strat = hard(value(P),value(D(1)));

end

if length(P) > 2 & strat == 2

strat = 1;

end

if ~isempty(hand)

show(hand,P)

show('Dealer',D)

strat = bjbuttonclick('hit',strat+1,length(P)>2);

end

switch strat

case 0

break

case 1

P = [P deal];

case 2

% Double down.

% Double bet and get one more card

bet = 2\*bet;

P = [P deal];

break

otherwise

break

end

end

% ------------------------

function s = payoff(who,P,D,split,bet)

% Payoff

detail = ~isempty(who);

fs = 20;

valP = value(P);

valD = value(D);

if valP == 21 & length(P) == 2 & ...

~(valD == 21 & length(D) == 2) & ~split

s = 1.5\*bet;

if detail, str = ['BLACKJACK: +' int2str(s)]; end

elseif valP > 21

s = -bet;

if detail, str = ['BUST: ' int2str(s)]; end

elseif valD > 21

s = bet;

str = ['WIN: +' int2str(s)];

if detail

text(min(1.5\*length(D)-4.5,2.75),-2.5,'BUST','fontsize',fs)

end

elseif valD > valP

s = -bet;

if detail, str = ['LOSE: ' int2str(s)]; end

elseif valD < valP

s = bet;

if detail, str = ['WIN: +' int2str(s)]; end

else

s = 0;

if detail, str = 'PUSH'; end

end

if detail

x = min(1.5\*length(P)-4.5,2.75);

if isequal(who,'Player')

y = 2.5;

else

y = 0;

end

text(x,y,str,'fontsize',fs)

end

% ------------------------

function show(who,H)

% Displays one hand

switch who

case 'Player', y = 2.5;

case 'Split', y = 0;

case 'Dealer', y = -2.5;

end

x = -4;

for j = 1:length(H)

card(x,y,H(j),length(H))

x = x + 1.5;

end

% ------------------------

function card(x,y,v,gray)

% card(x,y,v) plots v-th card at position (x,y).

z = exp((0:16)/16\*pi/2\*i)/16;

edge = [z+1/2+7\*i/8 i\*z-1/2+7\*i/8 -z-1/2-7\*i/8 -i\*z+1/2-7\*i/8 9/16+7\*i/8];

pips = {'A','2','3','4','5','6','7','8','9','10','J','Q','K'};

if v <= 0

% Hole card

patch(real(edge)+x,imag(edge)+y,[0 0 2/3])

else

fs = 20;

s = ceil(v/13);

v = mod(v-1,13)+1;

x1 = x;

if v==10, x1 = x1-.2; end

offwhite = [1 1 1];

if y == 0 & gray == 1, offwhite = [.75 .75 .75]; end

patch(real(edge)+x,imag(edge)+y,offwhite)

switch s

case {1,4}, redblack = [0 0 0];

case {2,3}, redblack = [2/3 0 0];

end

if 0

% PC has symbol font with card suits.

text(x1-.2,y,pips{v},'fontname','courier','fontsize',fs, ...

'fontweight','bold','color',redblack)

text(x,y+.025,char(166+s),'fontname','symbol','fontsize',fs, ...

'color',redblack)

else

text(x1-.1,y,pips{v},'fontname','courier','fontsize',fs, ...

'fontweight','bold','color',redblack)

end

end

% ------------------------

function val = bjbuttonclick(kase,basic,disable)

bjb = bjbuttons(kase);

if nargin == 3 & disable

set(bjb(3),'enable','off')

end

if nargin >= 2

set(bjb(basic),'fore','red')

end

while all(cell2mat(get(bjb,'val')) == 0)

drawnow

end

val = find(cell2mat(get(bjb,'val')))-1;

% ------------------------

function bjb = bjbuttons(kase)

bjb = findobj(gcf,'style','toggle');

if isempty(bjb)

for b = 3:-1:1

bjb(b,1) = uicontrol('units','normal','style','toggle', ...

'pos',[.95-.18\*b .02 .16 .08],'fontweight','bold');

end

end

set(bjb,'fore','black')

switch kase

case {1,2}

switch kase

case 1

fs = 12; y = .02; dy = .08;

case 2

fs = 10; y = .01; dy = .06;

end

for b = 1:3

set(bjb(b),'pos',[.95-.18\*b y .16 dy])

end

set(bjb,'val',0,'vis','on','enable','on','fontsize',fs)

set(bjb(1),'string','Close')

set(bjb(2),'string','Play')

set(bjb(3),'string','Simulate')

set(bjb(kase+1),'fore','red')

case 'detail'

set(bjb(1:2),'vis','on')

set(bjb(3),'vis','off')

for b = 1:3

set(bjb(b),'pos',[.95-.18\*b .02 .16 .08])

end

set(bjb,'val',0,'fontsize',12)

case 'off'

set(bjb,'vis','off')

case 'split'

set(bjb,'val',0,'fontsize',12)

set(bjb(1),'string','Keep')

set(bjb(2),'string','Split')

case 'hit'

set(bjb,'val',0,'vis','on','fontsize',12)

set(bjb(1),'string','Stand')

set(bjb(2),'string','Hit')

set(bjb(3),'string','Double')

end

% ------------------------

function strat = hard(p,d)

% Strategy for hands without aces.

% strategy = hard(player's\_total,dealer's\_upcard)

% 0 = stand

% 1 = hit

% 2 = double down

persistent HARD

if isempty(HARD)

n = NaN; % Not possible

% Dealer shows:

% 2 3 4 5 6 7 8 9 T A

HARD = [ ...

1 n n n n n n n n n n

2 1 1 1 1 1 1 1 1 1 1

3 1 1 1 1 1 1 1 1 1 1

4 1 1 1 1 1 1 1 1 1 1

5 1 1 1 1 1 1 1 1 1 1

6 1 1 1 1 1 1 1 1 1 1

7 1 1 1 1 1 1 1 1 1 1

8 1 1 1 1 1 1 1 1 1 1

9 2 2 2 2 2 1 1 1 1 1

10 2 2 2 2 2 2 2 2 1 1

11 2 2 2 2 2 2 2 2 2 2

12 1 1 0 0 0 1 1 1 1 1

13 0 0 0 0 0 1 1 1 1 1

14 0 0 0 0 0 1 1 1 1 1

15 0 0 0 0 0 1 1 1 1 1

16 0 0 0 0 0 1 1 1 1 1

17 0 0 0 0 0 0 0 0 0 0

18 0 0 0 0 0 0 0 0 0 0

19 0 0 0 0 0 0 0 0 0 0

20 0 0 0 0 0 0 0 0 0 0];

end

strat = HARD(p,d);

% ------------------------

function strat = soft(p,d)

% Strategy array for hands with aces.

% strategy = soft(player's\_total,dealer's\_upcard)

% 0 = stand

% 1 = hit

% 2 = double down

persistent SOFT

if isempty(SOFT)

n = NaN; % Not possible

% Dealer shows:

% 2 3 4 5 6 7 8 9 T A

SOFT = [ ...

1 n n n n n n n n n n

2 1 1 2 2 2 1 1 1 1 1

3 1 1 2 2 2 1 1 1 1 1

4 1 1 2 2 2 1 1 1 1 1

5 1 1 2 2 2 1 1 1 1 1

6 2 2 2 2 2 1 1 1 1 1

7 0 2 2 2 2 0 0 1 1 0

8 0 0 0 0 0 0 0 0 0 0

9 0 0 0 0 0 0 0 0 0 0];

end

strat = SOFT(p,d);

function strat = twoOfaKind(p,d)

% note that 0 = keep twoOfaKind

% also note that 1 = split twoOfaKind

persistent twoOfaKind

if isempty(twoOfaKind)

n = NaN; % Not possible

% Dealer shows:

% 2 3 4 5 6 7 8 9 T A

twoOfaKind = [ ...

1 n n n n n n n n n n

2 1 1 1 1 1 1 0 0 0 0

3 1 1 1 1 1 1 0 0 0 0

4 0 0 0 1 0 0 0 0 0 0

5 0 0 0 0 0 0 0 0 0 0

6 1 1 1 1 1 1 0 0 0 0

7 1 1 1 1 1 1 1 0 0 0

8 1 1 1 1 1 1 1 1 1 1

9 1 1 1 1 1 0 1 1 0 0

10 0 0 0 0 0 0 0 0 0 0

11 1 1 1 1 1 1 1 1 1 1];

end

strat = twoOfaKind(p,d);

%OUTPUT IS THE FOLLOWING SIMULATION which is summarized by the following %screenshots in sequential order:

% This first window is a user prompt, giving the user the option to play, %simulate, or close (“quit the game”).



%The following window has obviously shown that the user decided %to play. Please note that the user is on the top, and the dealer is on the bottom.



‘

% The user decided to hit, and as seen below, that was a mistake, due to the bust.



%The following is the graphical analysis of the simulation performed in matlab.

