Florida Institute of Technology

Harris Institute for Assured Information

CSE 5280
Computer Graphics
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Class Assignment-02
(Animation)

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1. <u>Simple motion path planning</u>:

<u>Code</u>:

```
function pathplanning()
%
% This program demonstrates a simple
% path-planning approach based on
% minimizing a cost function.

% Particle's initial position
particle(1).StartPosition = [ 10 10 ]';

% Particle's current position
particle(1).CurrentPosition = particle(1).StartPosition;

% This is the goal position.
particle(1).GoalPosition = [ 90 90 ]';

% (x,y) coordinates of the centroid of obstacles
o(1).location=[ 30 40 ]';
o(1).R=25;
o(2).location=[ 60 50 ]';
o(2).R=25;
o(3).location=[ 30 80 ]';
o(3).R=25;
o(4).location=[ 80 20 ]';
o(4).R=25;

% Advancement step for gradient descent
lambda = 3;

% We will store the calculated path locations
% in this array so we can plot them.
X = [];

% Termination condition
GoalReached = false;

% Plot initial location of particles
s = particle(1).StartPosition;
g = particle(1).GoalPosition;
figure,
plot( s(1), s(2),'ro', 'LineWidth', 2 )        % starting point
text( s(1)+2, s(2)-5, 'Start', 'FontSize', 12 );
hold on;

plot( g(1), g(2),'bo', 'LineWidth', 2 )    % goal point
text( g(1)+2, g(2)-5, 'Goal', 'FontSize', 12 );
axis([0 100 0 100 0 100]);
view([-20,40]);
%axis square;
set(gcf, 'Color', 'w' );
```

```
% Drawing Obstacles (filled circles).
filledCylinder(30,40,10);
filledCylinder(60,50,10);
filledCylinder(30,80,10);
filledCylinder(80,20,10);

% Initialize variables for locations
x = particle(1).StartPosition;
g = particle(1).GoalPosition;

% This loop calculates the new position of the particle.
% It repeats until goal is reached
n=1;
while ~GoalReached

    % Calculate next step using gradient descent
    x = x - lambda * Grad( x, g, o );

    % Store location. Concatenate the previous result with current's.
    X = [ X x ];

    % Plot particle at new location
    hold on;
    plot( x(1), x(2), 'g*' )    % trajectory points
    axis([0 100 0 100 0 1]);

    frame=getframe;
    im = frame2im(frame);
    [imind,cm] = rgb2ind(im,256);
    if n==1
       imwrite(imind,cm,'pathplanning.gif','gif', 'Loopcount',inf);
         n=2;
    else
       imwrite(imind,cm,'pathplanning.gif','gif','WriteMode','append');
    end

    % Pause for a moment so we can see the motion
    pause( .1 );

    % Check if goal has been reached, i.e., distance
    % between current and goal locations is less than a
    % pre-defined threshold.
    if ( norm( x - g ) <= 3 )
        GoalReached = true;
    end
end

% Gradient vector (2-D direction) of cost function at current position
function G = Grad( p, g, o)

% p:  2x1 vector with the current position
% g:  2x1 vector with goal position
```

```
% Calculate the cost of moving to locations of a 4-size neighborhood
%
%             ^
%             |
%             y1
%             |
%  -- x2 --- p --- x1 -->
%             |
%             y2
%             |
%
y1 = p + [  0;  1 ];
y2 = p + [  0; -1 ];

x1 = p + [  1;  0 ];
x2 = p + [ -1;  0 ];

% Calculate the components of the gradient vector
cx = Cpathplan( x1, g, o ) - Cpathplan( x2, g, o );
cy = Cpathplan( y1, g, o ) - Cpathplan( y2, g, o );

% Resultant vector formed by cost's x and y components
r = [ cx; cy ];

% Calculate the direction vector, i.e., direction of the gradient
vector
G = r / norm( r );

function c = Cpathplan( p, g, o )
% Cost function for path planning calculated at position s with respect
to
% goal g and obstacle o
%
% p:              2x1 vector with the current position
% g:              2x1 vector with goal position
% o(i).location: 2x1 vector with obstacle position
% o(i).R:         Radius of the obstacle

% Value of log10E
logE = 2.718281828;

% Goal cost (Euclidean distance squared)
c( 1 ) = norm(p-g);

% Collision cost
field=0;

for i=1:size(o,2)
   dist = sqrt( (p(1)-o(i).location(1))^2 + (p(2)-o(i).location(2))^2);
    if 0 < dist && dist <= o(i).R
        field_temp = logE ^ (log( o(i).R / dist )* logE);
    else
        field_temp=0;
    end
```

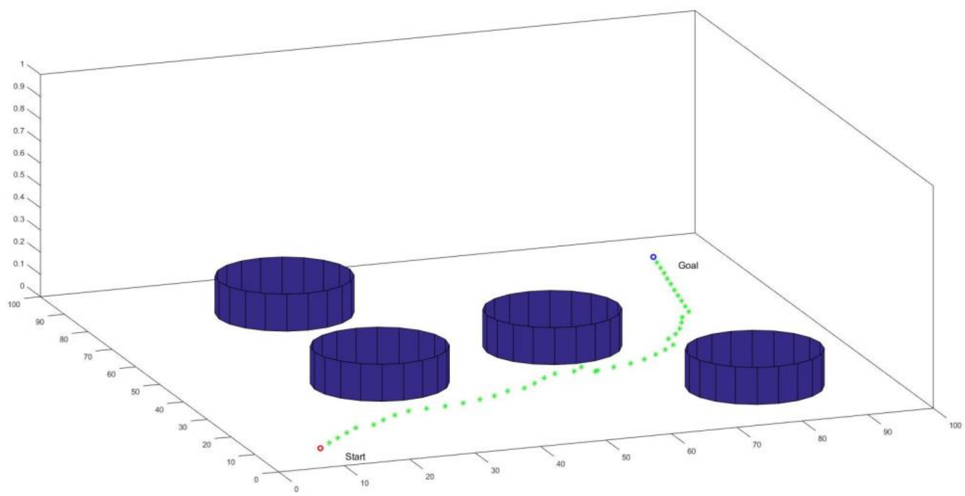
```
    field = field + field_temp;
end
%display(field);
c( 2 ) = field;               % TODO (Equation 3.2 of Breen's paper)

% Total cost
c = c(1) + c(2);

return

function h = filledCylinder(x,y,r)
% Drawing filled cylinder in figure.
    hold on
    [X,Y,Z] = cylinder(r);
    Z=Z/6;
    surf(X+x,Y+y,Z)
    hold off
return
```

Result:



2. Simulation of Helbing's social-force model:

Code:

```
function social_force_model()

close all;
%-----------------------------------------------------------------------
----
% The data structure System stores all the information about the scene.
% It makes it simpler to pass the whole system to the cost functions as
% they will need to know about the location of all particles and
obstacles.
%-----------------------------------------------------------------------
----
% Particle 1
System.particles.x(:,1) = [ 0 40 ]';   % current location
System.particles.g(:,1) = [ 100 40 ]';   % goal location

System.particles.x(:,2) = [ 0 50 ]';   % current location
System.particles.g(:,2) = [ 100 50 ]';   % goal location

System.particles.x(:,3) = [ 0 60 ]';   % current location
System.particles.g(:,3) = [ 100 60 ]';   % goal location

% Particle 2
System.particles.x(:,4) = [ 40 0 ]';   % current location
System.particles.g(:,4) = [ 40 100 ]';   % goal location

System.particles.x(:,5) = [ 50 0 ]';   % current location
System.particles.g(:,5) = [ 50 100 ]';   % goal location

System.particles.x(:,6) = [ 60 0 ]';   % current location
System.particles.g(:,6) = [ 60 100 ]';   % goal location


% Colors for particle trajectories. Using matlab's "Lines" colormap.
System.C = colormap(lines);

% Minimum distance indicating that particle has reached its destination
System.mindist = 1;

% Acceptable personal space (radius) between particles
System.personal_space = 5;


%-----------------------------------------------------------------------
----
% Start drawing scene (start and end points for particles)
DrawStartAndEndLocations( System );
axis([0 100 0 100]);                   % adjust limits of axes
```

```
% Step for gradient descent
lambda = 1;

GoalReached = false;

n=1;
while ~GoalReached
    % Calculate next step using gradient descent.
    % Simple two-particle system. Create a for-loop if using more
particles

    % display(size(System.particles.x,2));
    for j=1:size(System.particles.x,2)
        System.particles.x(:,j) = System.particles.x(:,j)   - lambda *
Grad( System, j );

        hold on;
        plot( System.particles.x(1,j), System.particles.x(2,j), '.',...
            'Color', System.C(j,:) );

        drawnow;
        % Has particle reached destination? Store true or false here.
        reached( j ) = norm( System.particles.x(:,j) -
System.particles.g(:,j) ) <= System.mindist;
    end

    if ( norm(System.particles.x(:,1) - System.particles.x(:,2) ) ) < 5
        d = 0;
    end

    frame=getframe;
    im = frame2im(frame);
    [imind,cm] = rgb2ind(im,256);
    if n==1
         imwrite(imind,cm,'socialForceModel.gif','gif',
'Loopcount',inf);
         n=2;
    else

imwrite(imind,cm,'socialForceModel.gif','gif','WriteMode','append');
    end

    % let's pause for a moment so we can see the motion
    pause( .05 );

    % check if goal has been reached (this only works for two
particles!!)
    if ( reached( 1 ) && reached( 2 ) )
        GoalReached = true;
    end

end
```

```
% Gradient vector (2-D direction) of cost function at current position
function G = Grad( System, j )
% j: particle id

% location of particle of interest
p = System.particles.x(:,j);

% Calculate the cost of moving to locations of a 4-size neighborhood
%
%            ^
%            |
%            y1
%            |
%  -- x2 --- p --- x1 -->
%            |
%            y2
%            |
%
y1 = p + [  0;  1 ];
y2 = p + [  0; -1 ];

x1 = p + [  1;  0 ];
x2 = p + [ -1;  0 ];

% Calculate the components of the gradient vector
cx = Cpathplan( System, x1, j ) - Cpathplan( System, x2, j );
cy = Cpathplan( System, y1, j ) - Cpathplan( System, y2, j );

% Resultant vector formed by cost's x and y components
r = [ cx; cy ];

% Calculate the direction vector, i.e., direction of the gradient
vector
G = r / norm( r );

return


function c = Cpathplan( System, x, j )
% Cost function for path planning
%
% x:    2x1 vector with the position for which we want to calculate
cost
% j:    particle id: either 1 or 2 for a two-particle example

% Goal cost for particle j (Euclidean distance squared)
g = System.particles.g(:,j);          % goal location for particle j
c( 1 ) = norm( x - g );


% Simple social force. It uses all particles except particle j
%c(2) = 0;
```

```
% Other cost ???
c( 3 ) = SocialForceCost( System, x, j );              % TODO

% Total cost
c = sum( c );

return

function DrawStartAndEndLocations( System )
% Just draws the start and end locations for visualization.

P = System.particles;     % particles locations
C = System.C;             % colors for plotting trajectories

% Number of particles in system
N = size( P.x, 2 );

for j = 1 : N
    hold on;

    % starting point
    plot( P.x(1,j)    , P.x(2,j), 'o', ...
        'Color', C(j,:), 'LineWidth', 2 );
    text( P.x(1,j)+.5, P.x(2,j), ...
        sprintf('S%d', j ), 'FontSize', 12 );
    hold on;

    % goal point
    plot( P.g(1,j)    , P.g(2,j),'o', ...
        'Color', C(j,:), 'LineWidth', 2 );
    text( P.g(1,j)+.5, P.g(2,j), ...
        sprintf('G%d', j ), 'FontSize', 12 );
end

return

function c = SocialForceCost( System, x, j )
% Simple social force (calculated for all particles except particle j)
%
% Input:
%   System: System info (all particles)
%   x:      2x1 vector with the position for which we want to calculate
cost
%   j:      Id of the particle of interest
%

% Number of particles in system
N = size( System.particles.x, 2 );

% Set difference, e.g., [ 1 2 3 ] - [2] = [ 1 3 ]. This produces an
array
% containing indices of all particles except particle j
idx = setdiff(  1:N , j );
OtherParticles = System.particles.x( :,  idx );
```

```
% Radius of the region of influence of "personal space"
sigma = System.personal_space;

field=0;
for i=1:size(OtherParticles,2);
  dist=sqrt((x(1)-OtherParticles(1,i))^2+(x(2)-OtherParticles(2,i))^2);
    % display(dist);
    if 0 < dist && dist <= sigma
        temp = log( sigma / dist);
    else
        temp=0;
    end
    field = field + temp;
end
c = field;
return
```

<u>Result</u>: