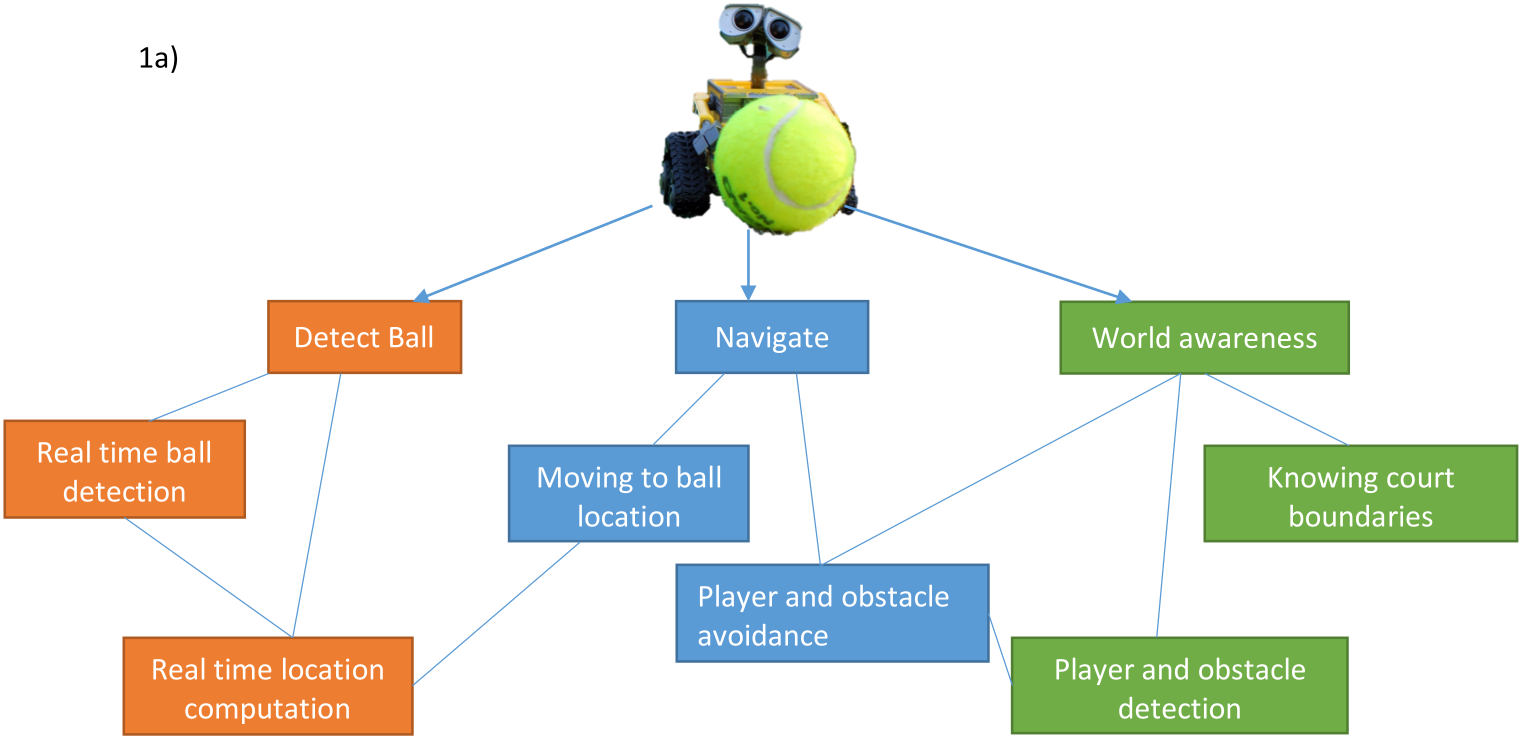
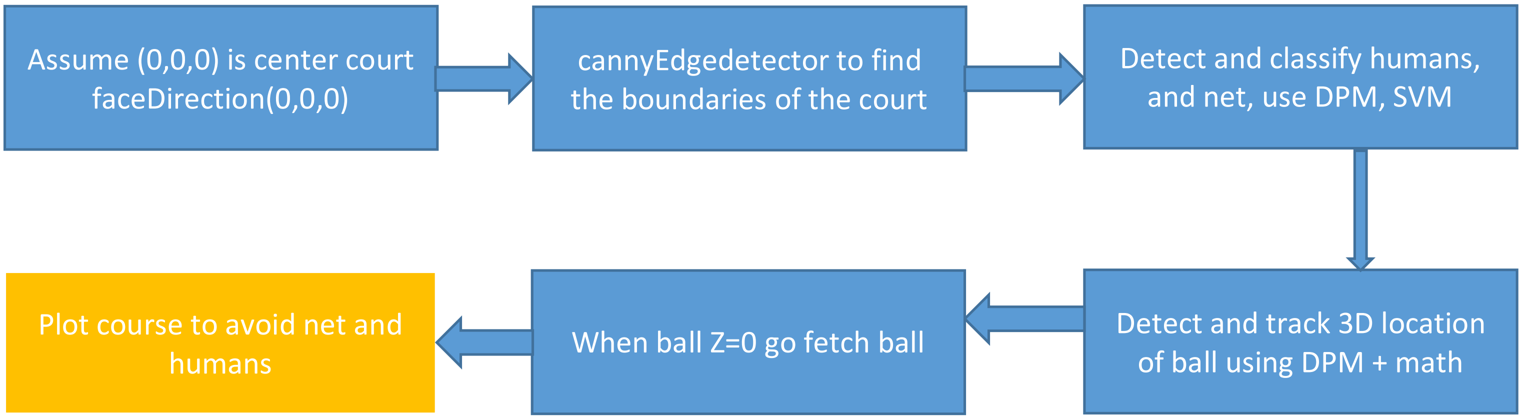
1a)


Detect Ball
Navigate
World awareness
Real time ball detection
Moving to ball location
Knowing court boundaries
Player and obstacle avoidance
Real time location computation
Player and obstacle detection

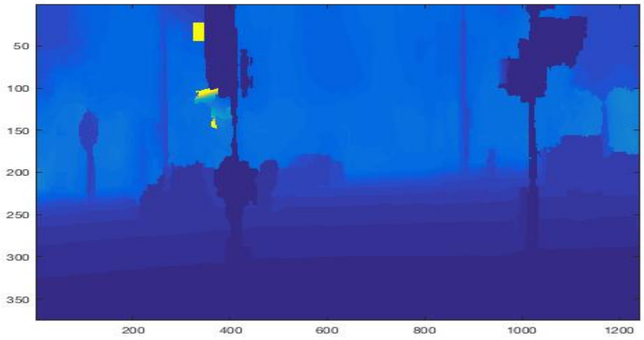
1b)

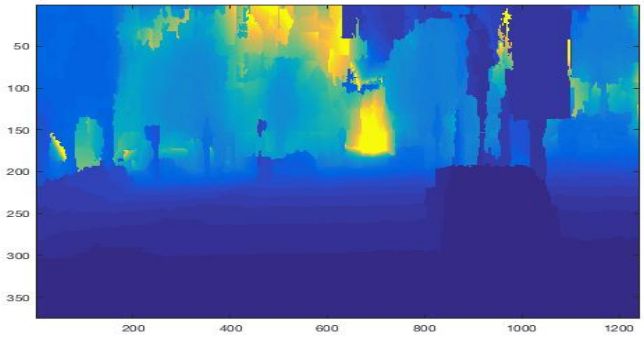

Assume (0,0,0) is center court faceDirection(0,0,0)
cannyEdgedetector to find the boundaries of the court
Detect and classify humans, and net, use DPM, SVM
Detect and track 3D location of ball using DPM + math
When ball Z=0 go fetch ball
Plot course to avoid net and humans

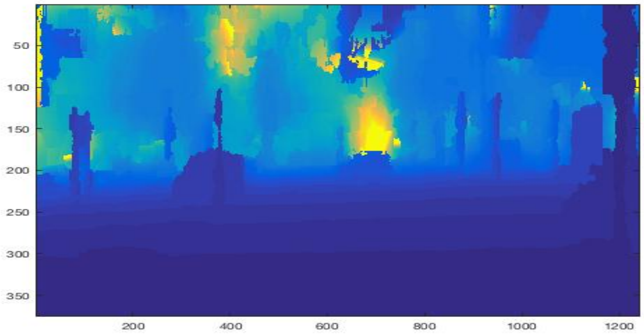
```
FaceDirection(0,0,0) #assume 0,0,0 is center of court
Capture image
cannyEdgedetect(image)
save location of boundaries
detect net in image
(Nx, Ny, Nz) = calculateNetLocation(detection)
while(1):
        capture image stream
        detect ball in image
        (X,Y,Z) = calculateBallLocation(detection)
        if(Z <=0+eps)
                from image stream detect humans
                (Hx[], Hy[], Hz[]) = calculateHumanLocations(detection)
                getBall(X,Y,Z, Hx, Hy, Hz); #i should pass the net location in here too


        return to standing location


getBall(getLocation, avoidLocations)
        if no avoid locations in the way:
                moveToLocation(getLocation)
                grabObjectAtLocation(getLocation)
                victoryDanceat(getLocation)
        else
                avoid = detectCollision(avoidLocations)
                moveToLocation(avoid [X] + 1m)
                getBall(getLocation, avoidLocations-avoid)
```

2a)

```
data = getData([], 'test','list');
ids = data.ids(1:3);

for i= 1:3
    calib = getData(ids{i}, 'test', 'calib');
    image = getData(ids{i}, 'test', 'disp');
    disparity = image.disparity;
    figure;imagesc(disparity);
    fT = calib.f*calib.baseline;
    depth = fT./disparity;
    dfosho = depth;
    dfosho(dfosho>255)=255+eps;
    figure;imagesc(dfosho);
end
```







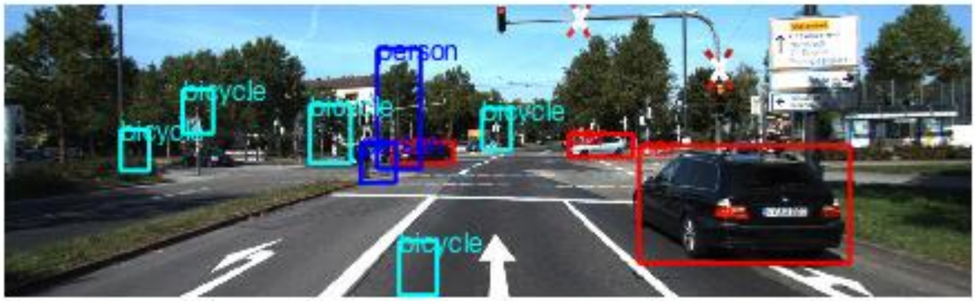
2b)

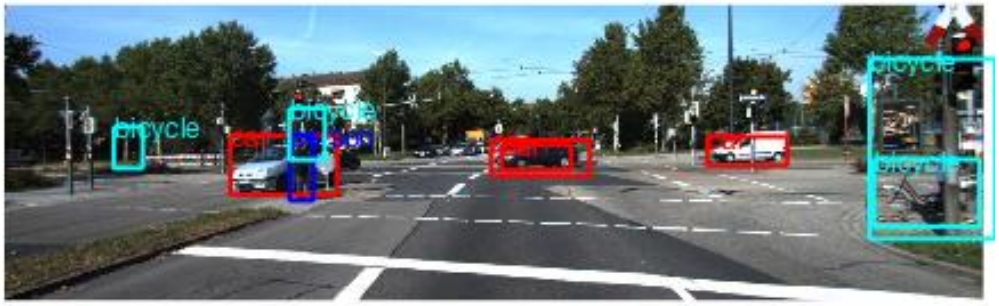
```
data = getData([], 'test','list');
ids = data.ids(1:3);
type = {'car', 'person', 'bicycle'};
thresh = {-0.5487,-0.7,-1.0916};
for j= 1:3
    for i= 1:3
        fdetector = sprintf('detector-%s',type{j});
        data = getData([], [], fdetector);
        model = data.model;
        col = 'r';
cali
        imdata = getData(ids{i}, 'test', 'left');
        im = imdata.im;
        f = 1.5;
        imr = imresize(im,f); % if we resize, it works better for small
objects

        % detect objects
        fprintf('running the detector, may take a few seconds...\n');
        tic;
        [ds, bs] = imgdetect(imr, model, thresh{j}); % you may need to reduce
the threshold if you want more detections
        e = toc;
        fprintf('finished! (took: %0.4f seconds)\n', e);
        nms_thresh = 0.5;
        top = nms(ds, nms_thresh);
        if model.type == model_types.Grammar
          bs = [ds(:,1:4) bs];
        end
        if ~isempty(ds)
            % resize back
            ds(:, 1:end-2) = ds(:, 1:end-2)/f;
            bs(:, 1:end-2) = bs(:, 1:end-2)/f;
        end;
        figure;showboxesMy(im, reduceboxes(model, bs(top,:)), col);
        fprintf('detections:\n');
        ds = ds(top, :);
        fname=sprintf('../data/test/results/%s-%s',ids{i}, type{j});
        save(fname, 'ds');
    end
end
```

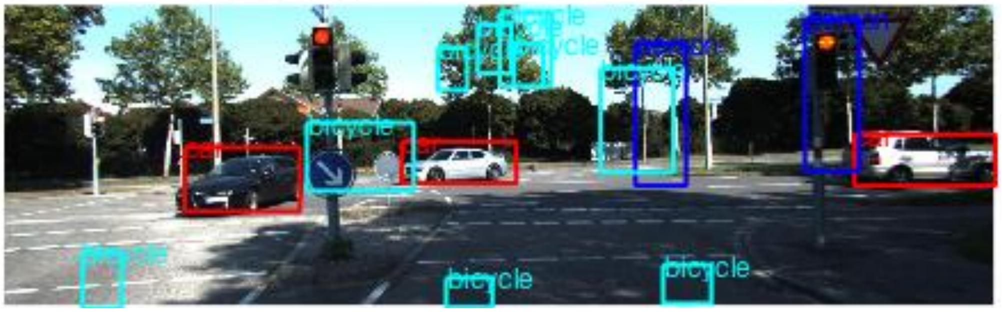
```
Sample:
1.0e+03 *

    0.4997    0.1714    0.6435    0.2232    0.0010    0.0011
    0.2270    0.1785    0.3719    0.2587    0.0030    0.0004
    1.0677    0.1623    1.2449    0.2263    0.0010    0.0001
```

2c)

```
data = getData([], 'test','list');
ids = data.ids(1:3);
col = {'r', 'b', 'c'};
for i = 1:3
    data = getData(ids{i}, 'test', 'ds');
    imdata = getData(ids{i}, 'test', 'left');
    im = imdata.im;
    figure; axis ij; hold on
    imagesc(im);
    for c = 1:3
        showboxesMy(im, data.dss{c}.ds(:,1:4), col{c});
        text(data.dss{c}.ds(:,1), data.dss{c}.ds(:,2),
data.class{c},'Color',col{c},'FontSize',12);
    end
    hold off;
end
```





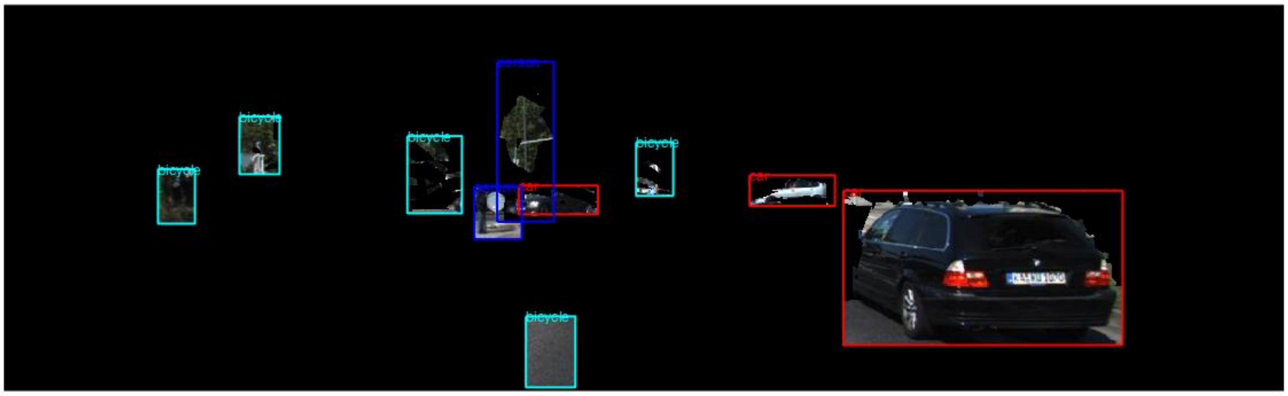


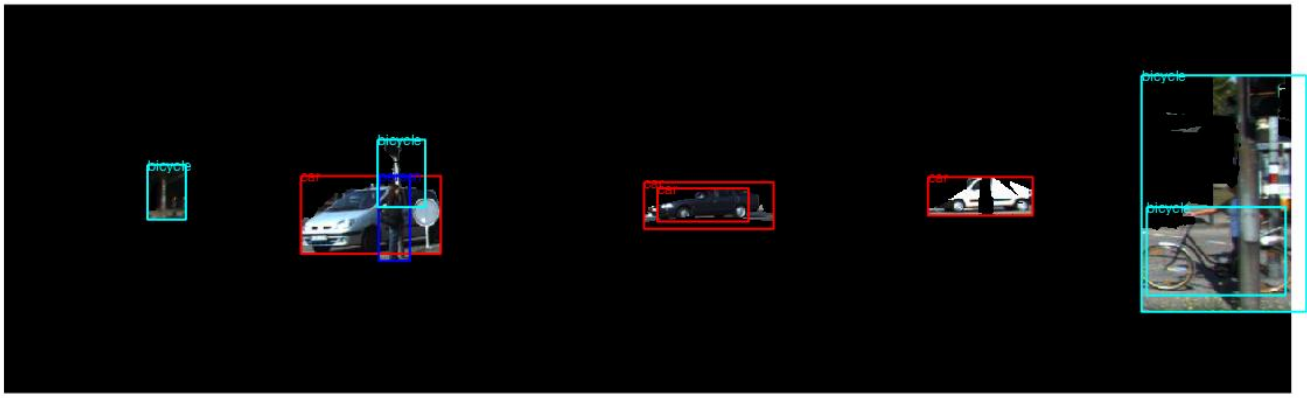
2d)

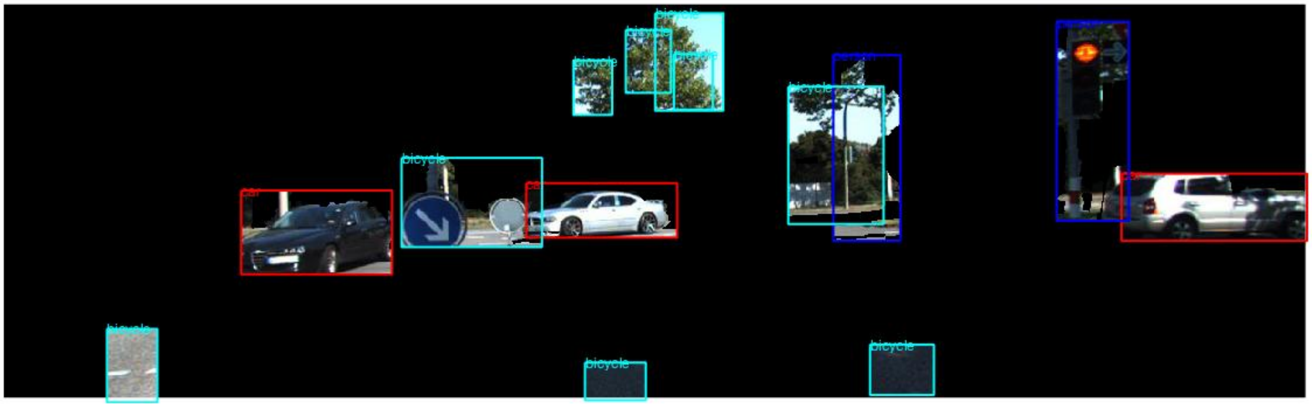
```
data = getData([], 'test','list');
ids = data.ids(1:3);
col = {'r', 'b', 'c'};
for i = 1:3
    data = getData(ids{i}, 'test', 'ds');
    imdata = getData(ids{i}, 'test', 'left');
    calib = getData(ids{i}, 'test', 'calib');
    im = imdata.im;
    depth = getDepth(ids{i});
    for c = 1:3
        for j = 1:size(data.dss{c}.ds,1)
            x1 = round(data.dss{c}.ds(j,2):data.dss{c}.ds(j,4));
            y1 = round(data.dss{c}.ds(j,1):data.dss{c}.ds(j,3));
            x1 = x1(x1<=375);
            y1 = y1(y1<=1242);
            segmentdepth = depth(x1,y1);
            Z = mode(round(segmentdepth(:)));
            centers = [data.dss{c}.ds(j,1)+(data.dss{c}.ds(j,3)-
data.dss{c}.ds(j,1))/2 data.dss{c}.ds(j,2)+(data.dss{c}.ds(j,4)-
data.dss{c}.ds(j,2))/2];

            X = (Z.*(centers(1) - calib.K(1,3)))/calib.f;
            Y = (Z.*(centers(2) - calib.K(2,3)))/calib.f;
            data.dss{c}.ds(j,7) = X;
            data.dss{c}.ds(j,8) = Y;
            data.dss{c}.ds(j,9) = Z;

        end
        ds = data.dss{c}.ds;
        fname=sprintf('../data/test/results/%s-%s',ids{i}, data.class{c});
        save(fname, 'ds');
    end

end
```

2e)

```
data = getData([], 'test','list');
ids = data.ids(1:3);
col = {'r', 'b', 'c'};
for i = 1:3
    data = getData(ids{i}, 'test', 'ds');
    imdata = getData(ids{i}, 'test', 'left');
    im = imdata.im;
    depth = getDepth(ids{i});
    plx = repmat((1:size(depth,1))', 1, size(depth,2));
    ply = repmat((1:size(depth,2)), size(depth,1), 1);
    Xmat = (depth.*(plx - calib.K(1,3)))/calib.f;
    Ymat = (depth.*(ply - calib.K(2,3)))/calib.f;
    segmask = uint8(zeros(size(depth)));
    segim = uint8(zeros(size(im)));
    for c = 1:3

        X = data.dss{c}.ds(:,7);
        Y = data.dss{c}.ds(:,8);
        Z = data.dss{c}.ds(:,9);
        data.dss{c}.ds(:,1:4)=floor(data.dss{c}.ds(:,1:4));
        for j = 1:size(Z)
            [rowz, colz] = find(depth>=Z(j)-3 & depth<=Z(j)+3);
            [rowx, colx] = find(Xmat>=X(j)-3 & Xmat<=X(j)+3);
            [rowy, coly] = find(Ymat>=Y(j)-3 & Ymat<=Y(j)+3);
            indices = sub2ind(size(segmask), rowz, colz);
            segmask(indices) = 1;
            indices = sub2ind(size(segmask), rowx, colx);
            segmask(indices) = 1;
            indices = sub2ind(size(segmask), rowy, coly);
            segmask(indices) = 1;
            x1 = data.dss{c}.ds(j,2):data.dss{c}.ds(j,4);
            y1 = data.dss{c}.ds(j,1):data.dss{c}.ds(j,3);
            x1 = x1(x1<=375);
            y1 = y1(y1<=1242);
            for dim = 1:3
                segim(x1 ,y1 ,dim)= im(x1 ,y1,dim).*segmask(x1,y1);
            end


        end


    end
    figure; axis ij; hold on
    imagesc(segim);
    for c = 1:3
        showboxesMy(im, data.dss{c}.ds(:,1:4), col{c});
        text(data.dss{c}.ds(:,1), data.dss{c}.ds(:,2),
data.class{c},'Color',col{c},'FontSize',12);
    end
    hold off;

end
```


bicycle
person
bicycle
bicycle
bicycle
car
car
car
bicycle


bicycle
bicycle
bicycle
car
car
car
car
bicycle


bicycle
bicycle
bicycle
bicycle
bicycle
car
bicycle
car
car
bicycle
bicycle
bicycle

```
2f)

data = getData([], 'test','list');
ids = data.ids(1:3);
col = {'r', 'b', 'c'};
for i = 1:3
    data = getData(ids{i}, 'test', 'ds');
    imdata = getData(ids{i}, 'test', 'left');
    im = imdata.im;
    d={};
    for c = 1:3
        X = data.dss{c}.ds(:,7);
        Y = data.dss{c}.ds(:,8);
        Z = data.dss{c}.ds(:,9);
        for j = 1:size(Z)
            d{end+1,1} = norm([X(j), Y(j), Z(j)]);
            d{end,2} = data.class{c};
            d{end,3} = X(j);
        end
    end
    d = sortrows(d); %information about whatever is closest is presented
first
    for j = 1:size(d,1)
        if d{j,3} >= 0, txt = 'to your right'; else txt = 'to your left';
end;
        fprintf('There is a %s %0.1f meters %s \n', d{j,2}, d{j,3}, txt);
        fprintf('It is %0.1f meters away from you \n', d{j,1});
    end

end
```

IMAGE1 from above page:

```
There is a bicycle -0.8 meters to your left
It is 7.2 meters away from you
There is a car 3.3 meters to your right
It is 7.8 meters away from you
There is a person -4.7 meters to your left
It is 26.4 meters away from you
There is a bicycle -15.9 meters to your left
It is 30.5 meters away from you
There is a car -3.4 meters to your left
It is 35.2 meters away from you
There is a car 10.2 meters to your right
It is 48.1 meters away from you
There is a bicycle 2.5 meters to your right
It is 78.1 meters away from you
There is a person -11.1 meters to your left
It is 78.9 meters away from you
There is a bicycle -41.0 meters to your left
It is 91.8 meters away from you
There is a bicycle -25.1 meters to your left
It is 98.3 meters away from you
```

IMAGE2 from above page:

```
There is a bicycle 7.1 meters to your right
It is 11.5 meters away from you
There is a bicycle 8.6 meters to your right
It is 14.0 meters away from you
There is a bicycle -5.3 meters to your left
It is 17.8 meters away from you
There is a person -5.5 meters to your left
It is 17.9 meters away from you
There is a car -6.4 meters to your left
It is 19.1 meters away from you
There is a car 2.9 meters to your right
It is 32.1 meters away from you
There is a car 3.1 meters to your right
It is 32.2 meters away from you
There is a car 16.2 meters to your right
It is 38.6 meters away from you
There is a bicycle -64.5 meters to your left
It is 121.5 meters away from you
```

IMAGE3 from above page:

```
There is a bicycle -0.2 meters to your left
It is 6.2 meters away from you
There is a bicycle 2.4 meters to your right
It is 7.6 meters away from you
There is a bicycle -1.8 meters to your left
It is 8.2 meters away from you
There is a bicycle -4.7 meters to your left
It is 8.6 meters away from you
There is a person 4.8 meters to your right
It is 9.3 meters away from you
There is a car -6.4 meters to your left
It is 16.4 meters away from you
There is a car 13.6 meters to your right
It is 22.6 meters away from you
There is a car -1.3 meters to your left
It is 25.0 meters away from you
There is a bicycle 0.4 meters to your right
It is 39.5 meters away from you
There is a bicycle 2.5 meters to your right
It is 40.6 meters away from you
There is a bicycle -2.6 meters to your left
It is 41.4 meters away from you
```

```
There is a bicycle 2.8 meters to your right
It is 41.5 meters away from you
There is a person 13.1 meters to your right
It is 46.0 meters away from you
There is a bicycle 12.3 meters to your right
It is 49.6 meters away from you
```