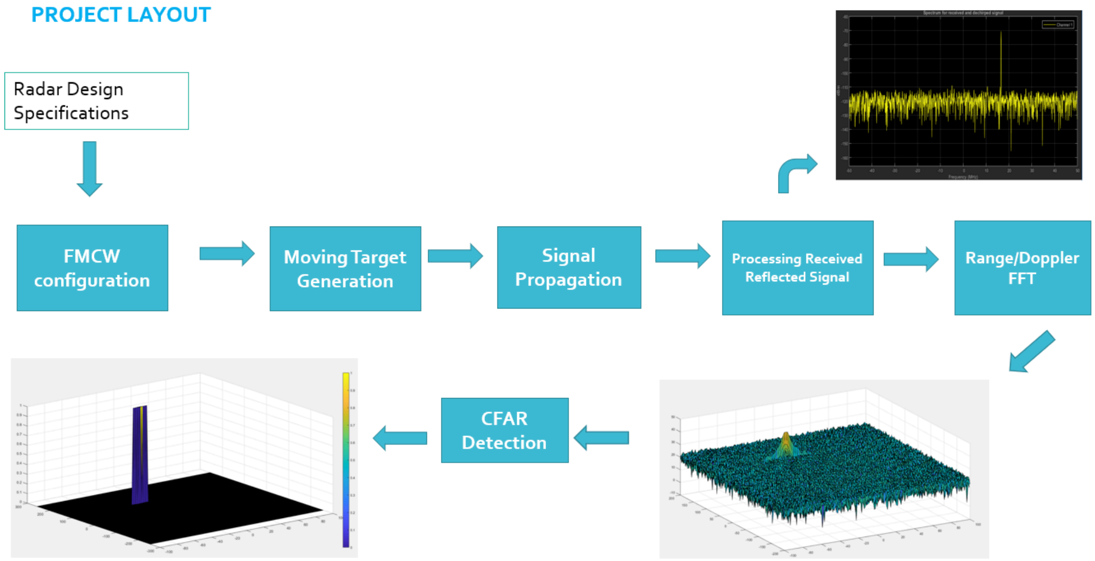
Table of Contents

Project Layout 1
Radar Specifications 1
User Defined Range and Velocity of target 2
FMCW Waveform Generation 2
Signal generation and Moving Target simulation 3
RANGE MEASUREMENT 4
RANGE DOPPLER RESPONSE 5
CFAR implementation 6

Project Layout




```
clear all
close all
clc;
```

Radar Specifications

Frequency	77 GHz
Range Resolution	1 m
Max Range	200 m
Max velocity	70 m/s
Velocity resolution	3 m/s

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Frequency of operation = 77GHz
% Max Range = 200m
% Range Resolution = 1 m
% Max Velocity = 100 m/s
%%%%%%%%%%%%%%%%%%%%%%%%%%%


%speed of light = 3e8
```

User Defined Range and Velocity of target

%TODO : define the target's initial position and velocity. Note : Velocity remains contant

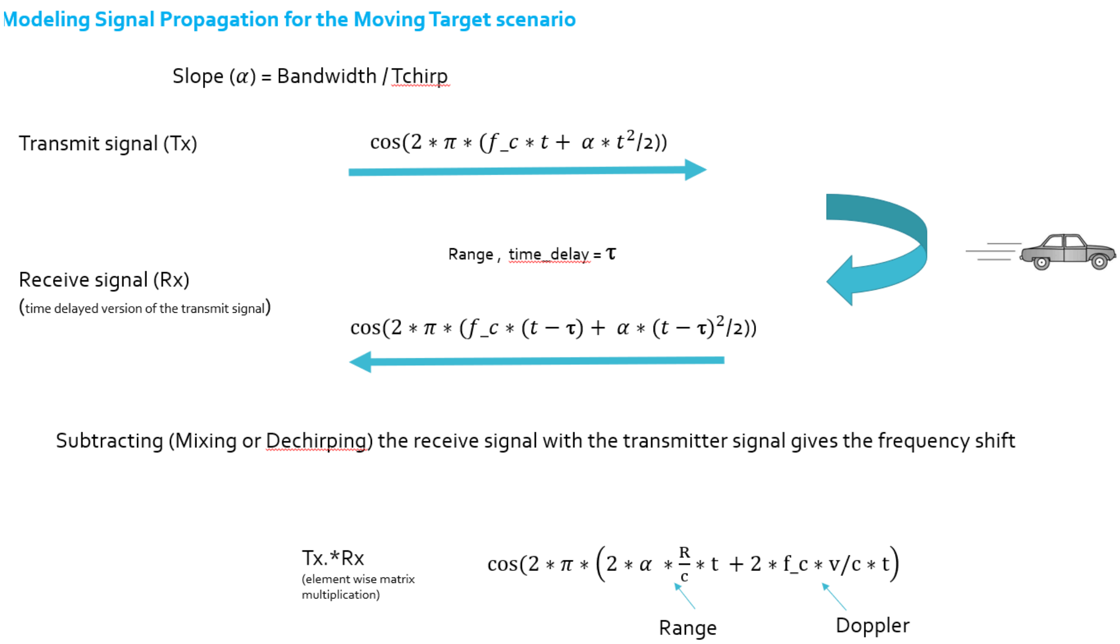
```
R = 150;
v = 10;
```

FMCW Waveform Generation

```
% *%TODO* :
%Design the FMCW waveform by giving the specs of each of its
 parameters.
% Calculate the Bandwidth (B), Chirp Time (Tchirp) and Slope (slope)
 of the FMCW
% chirp using the requirements above.
light_speed = 3e8; %[m/s]
range_resolution = 1; % [m]
max_range = 200; % [m]

B = light_speed/(2*range_resolution);
Tsweep = 5;    % 5-6 times the round trip time
Tchirp = 2*Tsweep*max_range/light_speed;
slope = B/Tchirp;

%Operating carrier frequency of Radar
fc= 77e9;             %carrier freq


%The number of chirps in one sequence. Its ideal to have 2^ value for
 the ease of running the FFT
%for Doppler Estimation.
Nd=128;                   % #of doppler cells OR #of sent periods %
 number of chirps

%The number of samples on each chirp.
Nr=1024;                  %for length of time OR # of range cells

% Timestamp for running the displacement scenario for every sample on
 each
% chirp
t=linspace(0,Nd*Tchirp,Nr*Nd); %total time for samples
```

```
%Creating the vectors for Tx, Rx and Mix based on the total samples
 input.
Tx=zeros(1,length(t)); %transmitted signal
Rx=zeros(1,length(t)); %received signal
Mix = zeros(1,length(t)); %beat signal

%Similar vectors for range_covered and time delay.
r_t=zeros(1,length(t));
td=zeros(1,length(t));
```

Signal generation and Moving Target simulation



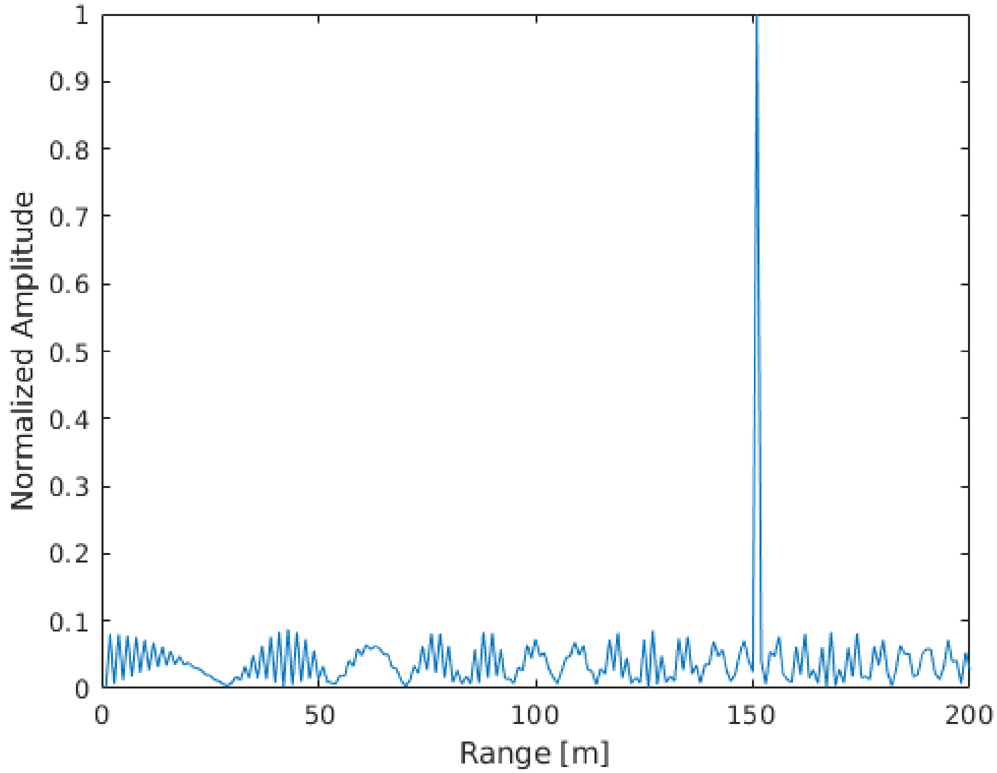
Running the radar scenario over the time.

```
for i=1:length(t)


    % *%TODO* :
    %For each time stamp update the Range of the Target for constant
 velocity.
    r_t(i) = R + v*t(i);
    td(i) = 2*r_t(i)/light_speed;

    % *%TODO* :
    %For each time sample we need update the transmitted and
    %received signal.
    Tx(i) = cos(2*pi*(fc*t(i)+0.5*slope*t(i)^2));
    Rx(i) = cos(2*pi*(fc*(t(i)-td(i))+0.5*slope*(t(i)-td(i))^2));
```

```
    % *%TODO* :
    %Now by mixing the Transmit and Receive generate the beat signal
    %This is done by element wise matrix multiplication of Transmit
 and
    %Receiver Signal
    Mix(i) = Tx(i).*Rx(i);
end
```

RANGE MEASUREMENT

```
 % *%TODO* :
%reshape the vector into Nr*Nd array. Nr and Nd here would also define
 the size of
%Range and Doppler FFT respectively.
Mix = reshape(Mix, [Nr, Nd]);

 % *%TODO* :
%run the FFT on the beat signal along the range bins dimension (Nr)
 and
%normalize.
sig_fft = fft(Mix,Nr);

 % *%TODO* :
% Take the absolute value of FFT output
sig_fft = abs(sig_fft);

 % *%TODO* :
% Output of FFT is double sided signal, but we are interested in only
 one side of the spectrum.
% Hence we throw out half of the samples.
sig_fft = sig_fft./max(sig_fft); %normalize
sig_fft = sig_fft(1:Nr/2-1);


%plotting the range
figure ('Name','Range from First FFT')
%subplot(2,1,1)

 % *%TODO* :
 % plot FFT output
plot(sig_fft);
axis ([0 200 0 1]);
ylabel('Normalized Amplitude');
xlabel('Range [m]');
```

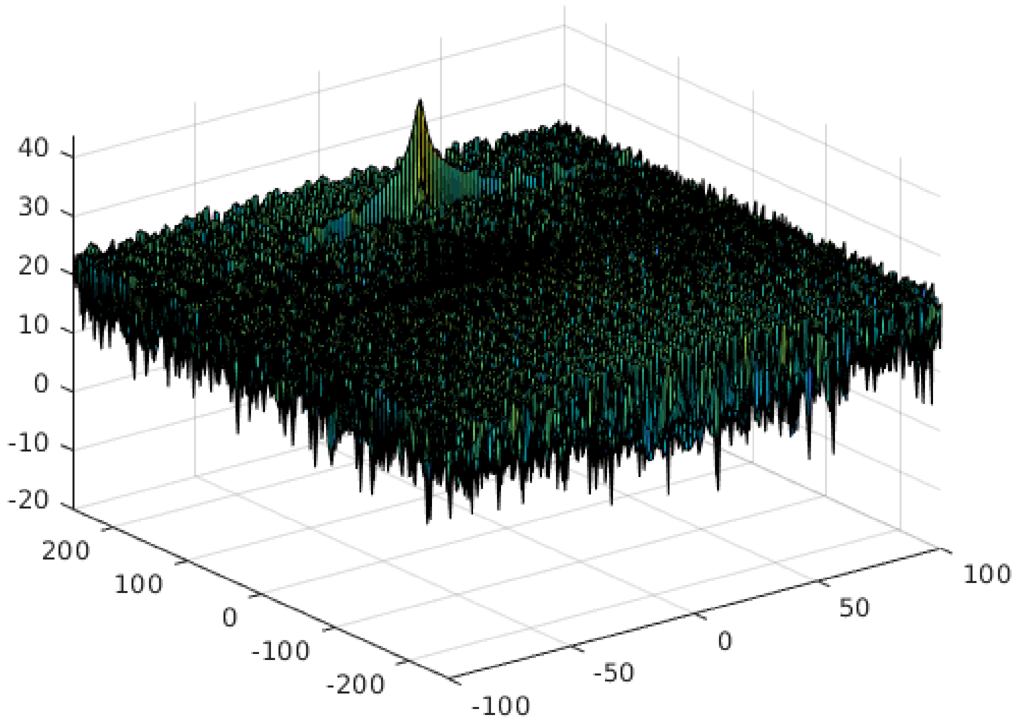


RANGE DOPPLER RESPONSE

The 2D FFT implementation is already provided here. This will run a 2DFFT on the mixed signal (beat signal) output and generate a range doppler map.You will implement CFAR on the generated RDM

```
% Range Doppler Map Generation.

% The output of the 2D FFT is an image that has reponse in the range
 and
% doppler FFT bins. So, it is important to convert the axis from bin
 sizes
% to range and doppler based on their Max values.

Mix=reshape(Mix,[Nr,Nd]);

% 2D FFT using the FFT size for both dimensions.
sig_fft2 = fft2(Mix,Nr,Nd);

% Taking just one side of signal from Range dimension.
sig_fft2 = sig_fft2(1:Nr/2,1:Nd);
sig_fft2 = fftshift (sig_fft2);
RDM = abs(sig_fft2);
RDM = 10*log10(RDM) ;

%use the surf function to plot the output of 2DFFT and to show axis in
 both
```

```
%dimensions
doppler_axis = linspace(-100,100,Nd);
range_axis = linspace(-200,200,Nr/2)*((Nr/2)/400);
figure('Name','2D FFT output - Range Doppler Map');
surf(doppler_axis,range_axis,RDM);
```

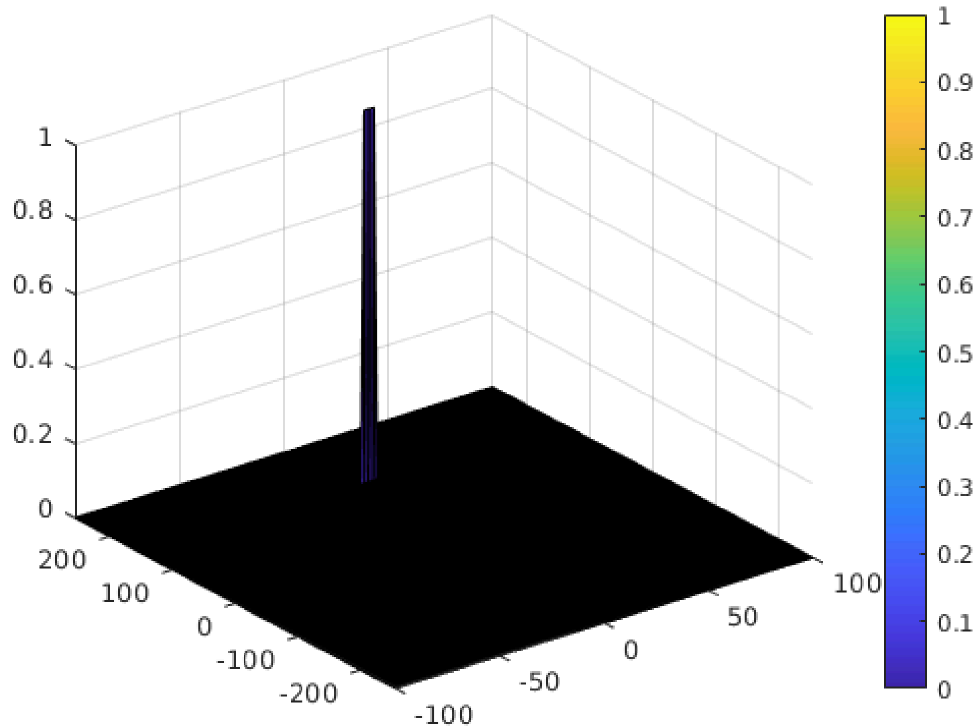


CFAR implementation

```
%Slide Window through the complete Range Doppler Map

% *%TODO* :
%Select the number of Training Cells in both the dimensions.
Tr = 10;
Td = 8;

% *%TODO* :
%Select the number of Guard Cells in both dimensions around the Cell
 under
%test (CUT) for accurate estimation
Gr = 4;
Gd = 4;

% *%TODO* :
% offset the threshold by SNR value in dB
offset = 1.4;
```

```
% *%TODO* :
%Create a vector to store noise_level for each iteration on training
 cells
noise_level = zeros(1,1);


% *%TODO* :
%design a loop such that it slides the CUT across range doppler map by
%giving margins at the edges for Training and Guard Cells.
%For every iteration sum the signal level within all the training
%cells. To sum convert the value from logarithmic to linear using
 db2pow
%function. Average the summed values for all of the training
%cells used. After averaging convert it back to logarithimic using
 pow2db.
%Further add the offset to it to determine the threshold. Next,
 compare the
%signal under CUT with this threshold. If the CUT level > threshold
 assign
%it a value of 1, else equate it to 0.


% Use RDM[x,y] as the matrix from the output of 2D FFT for
 implementing
% CFAR
RDM = RDM/max(max(RDM));

for i = Tr+Gr+1:Nr/2-(Gr+Tr)
    for j = Td+Gd+1:Nd-(Gd+Td)
        % reset noise level for the next slide
        noise_level = zeros(1,1);
        for p = i-(Tr+Gr):i+Tr+Gr
            for q = j-(Td+Gd):j+Td+Gd
                if (abs(i-p)>Gr || abs(j-q)>Gd)
                    noise_level = noise_level + db2pow(RDM(p,q));
                end
            end
        end
        threshold = pow2db(noise_level/(2*(Td+Gd+1)*2*(Tr+Gr+1)-
(Gr*Gd)-1));
        threshold = threshold + offset;
        CUT = RDM(i,j);
        if (CUT < threshold)
            RDM(i,j) = 0;
        else
            RDM(i,j) = 1;
        end
    end
end


% *%TODO* :
% The process above will generate a thresholded block, which is
 smaller
```

```
%than the Range Doppler Map as the CUT cannot be located at the edges
 of
%matrix. Hence,few cells will not be thresholded. To keep the map size
 same
% set those values to 0.
[rows, cols] = size(RDM);
RDM(union(1:(Tr+Gr),rows-(Tr+Gr-1):rows),:) = 0;
RDM(:,union(1:(Td+Gd),cols-(Td+Gd-1):cols)) = 0;


% *%TODO* :
%display the CFAR output using the Surf function like we did for Range
%Doppler Response output.
figure('Name','The output of the 2D CFAR process')
surf(doppler_axis,range_axis,RDM);
colorbar;
```



Published with MATLAB® R2020a