Target Detection and Tracking System: Image Generation

Surya Teja Togaru

Background

Considering a target with a Gaussian plume intensity, in the sensor's focal plane

$$S(x,y) = S_{max} e^{-\frac{1}{2}\left[\frac{(x-x_c)^2}{a_x^2} + \frac{(y-y_c)^2}{a_y^2}\right]}$$

with the center at (x_c, y_c) and semiaxes as a_x and a_y, assumed to be oriented along the sensor's coordinates[1]. The sampling period is generalized to be one second[2].

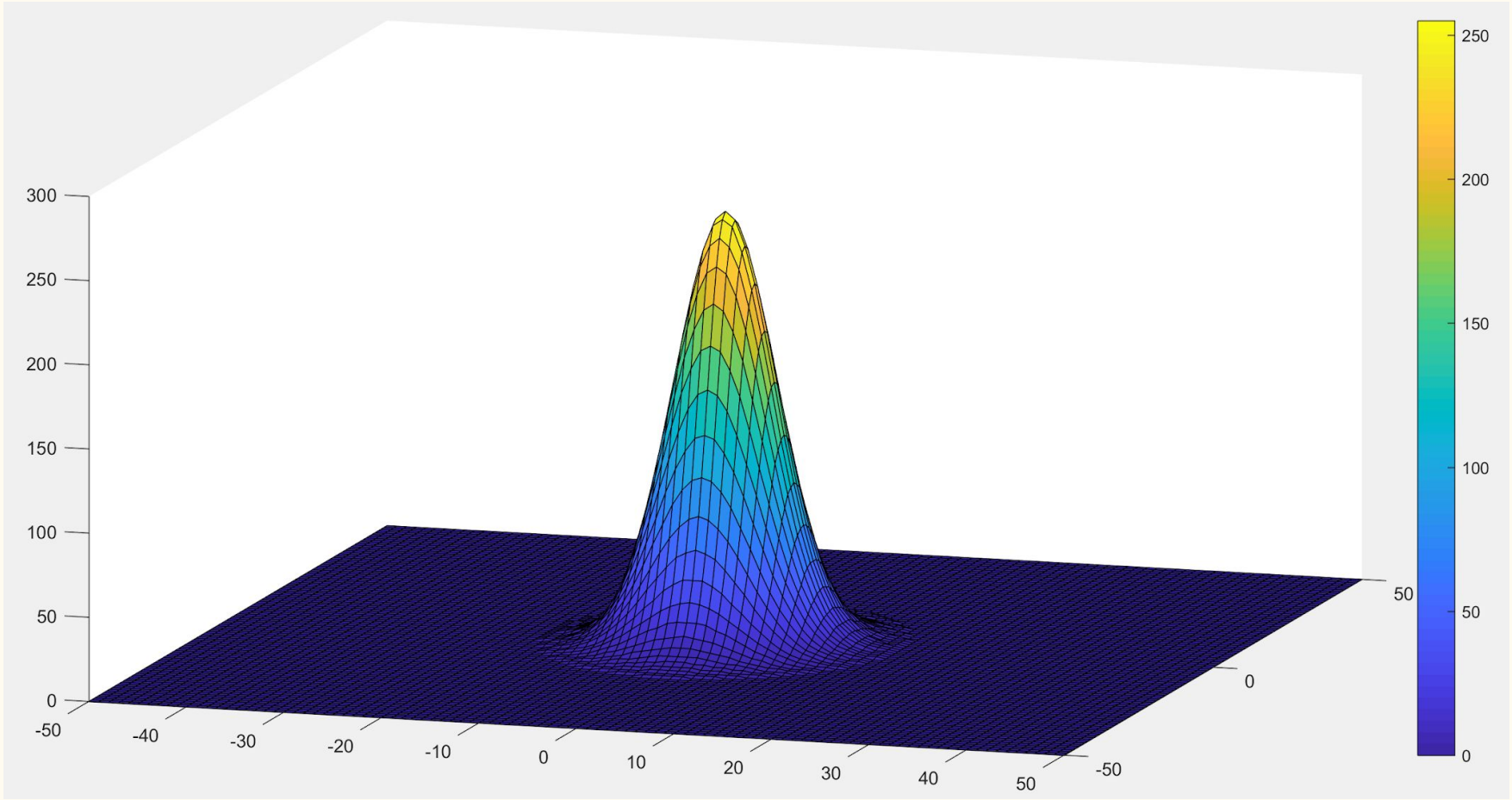


Figure: *A gaussian plume model*

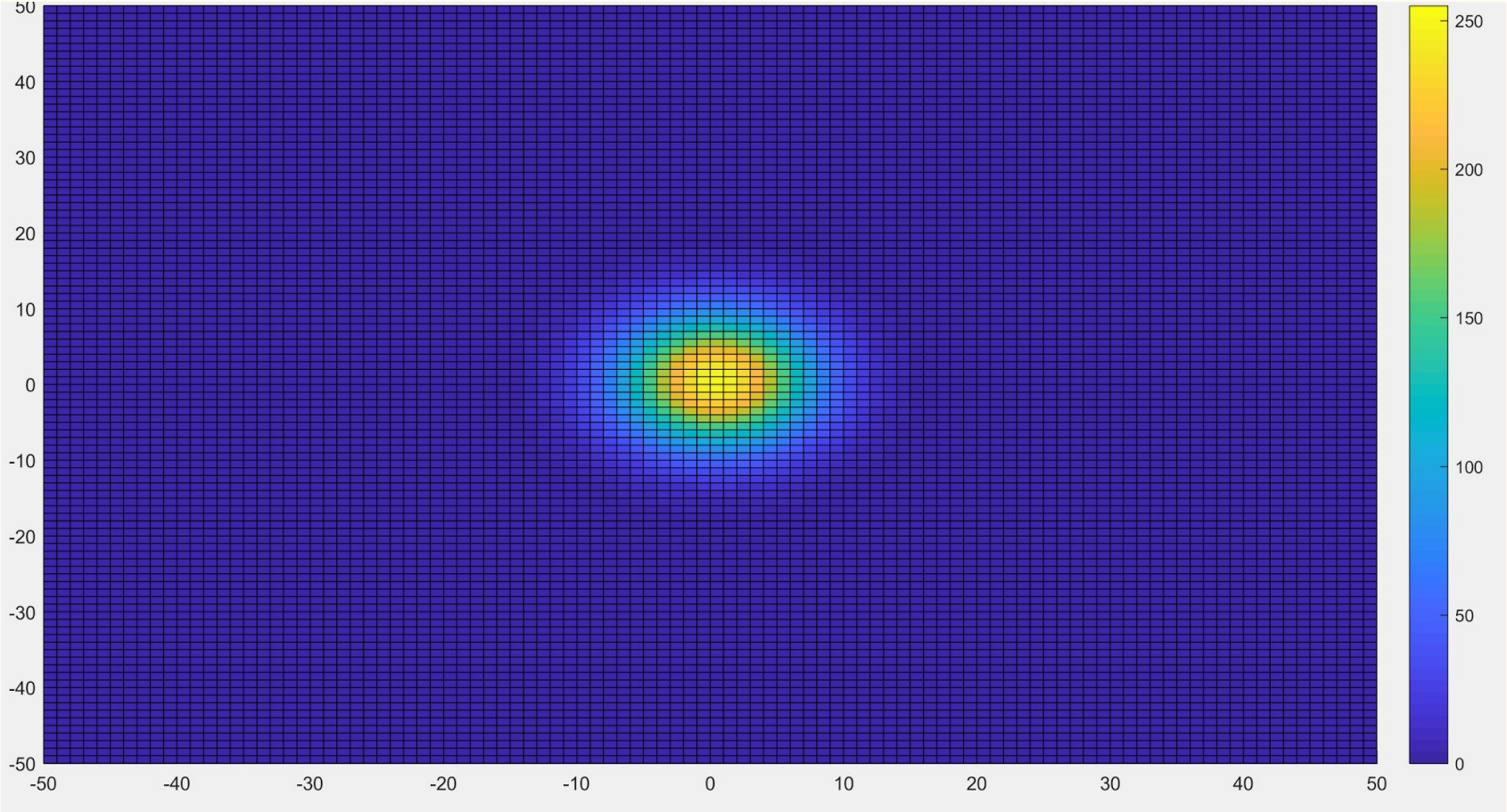


Figure: *X-Y view of the gaussian plume model*

Signal to Noise Ratio

The frame signal to noise ratio of the image produced by the sensor is given by the equation:

$$r = \frac{s}{\sigma\sqrt{m}}$$

Where ‘s’ is the sum of the intensities of all the pixels in the image, σ is the variance of the noise and ‘m’ is the grid area (i.e if the length of the edge is ‘n’ then n^2 is the grid area.)[4]

Noise Modelling

The image noise modeled and used is **additive white gaussian noise** with zero mean and a fixed variance.

- ***Additive*** because it is added to any noise that might be intrinsic to the information system.
- ***White*** refers to the idea that it has uniform power across the frequency band for the information system. It is an analogy to the color white which has uniform emissions at all frequencies in the visible spectrum.
- ***Gaussian*** because it has a normal distribution in the time domain with an average time domain value of zero.

Using the Functions

Image Generation

Function name: img_gen()

This function is used for the generation of input images which will be further used by the other functions in this project which implement various filter methods. The images generated are grayscale images of the gaussian plume target.

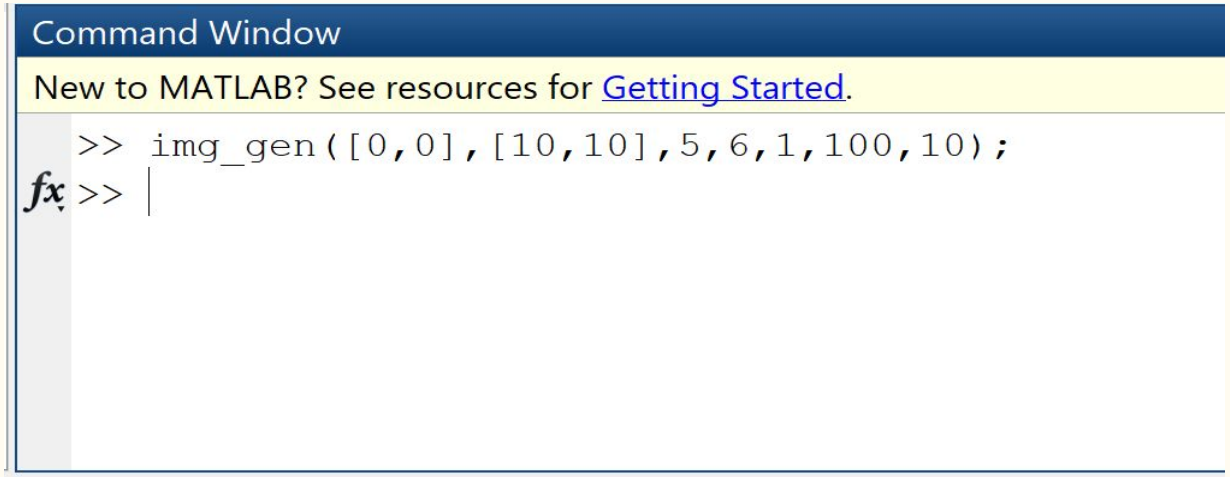
Calling the img_gen() function

Function Definition: img_gen(start_pt, end_pt, a_x, a_y, vel, img_edge,targ_int)

The img_gen function takes in the following input parameters:

- start_pt: This is the start point of the target in cartesian coordinates.
- end_pt: This parameter takes in the destination of the target in cartesian coordinates
- a_x and a_y: These are the semiaxes of the Gaussian plume target which, for simplicity are taken to be oriented along the sensor's coordinates[1].
- vel: This parameter is the velocity of the target during its traversal.
- img_edge: The length of the edge of the frame in pixels is specified.
- targ_int : The maximum intensity of the target is passed to the function via this argument[3].

Note: Navigate to the folder in which the images are generated before calling the img_gen function.

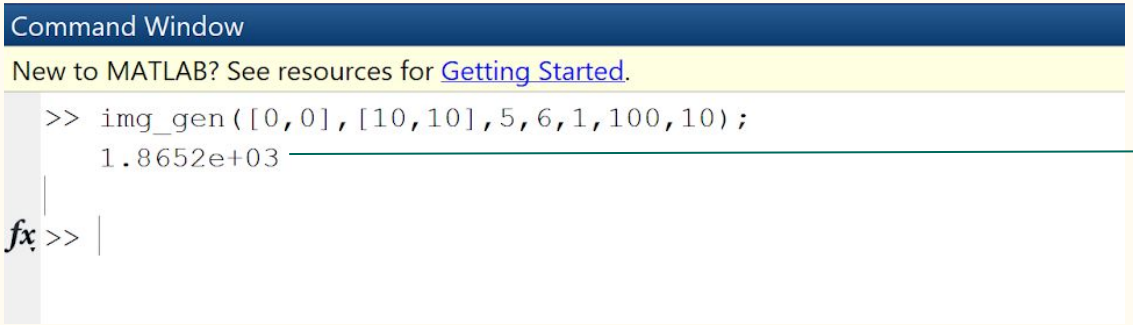


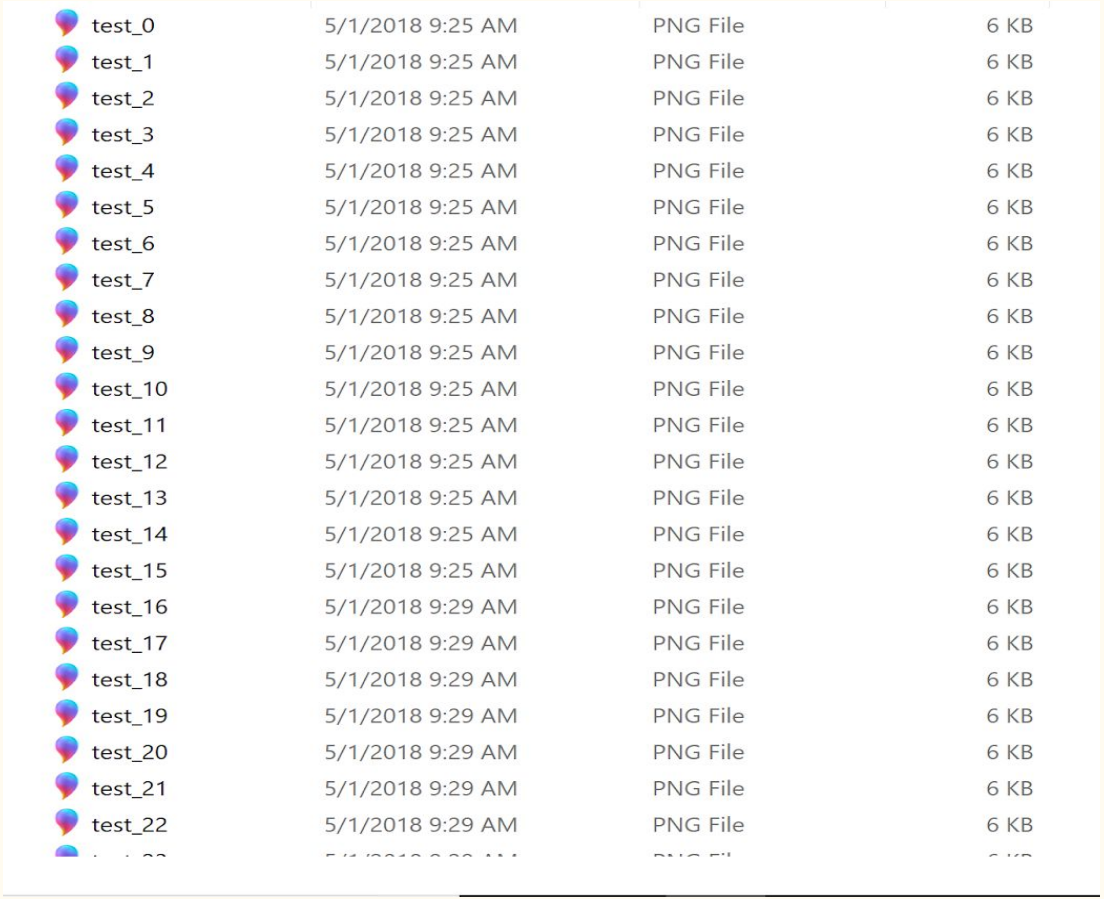
- Start_pt - [0,0]
- End_pt - [10,10]
- A_x - 5
- A_y - 6
- Vel - 1
- Img_edge - 100
- Targ_int - 10[3]

Therefore, the images generated are of a gaussian plume target with semiaxes, 5 and 6, and maximum intensity ,10, moving from the point (0,0) to the point (10,10) with a velocity 1.

Output of img_gen() function

- The output is images generated from the given parameters stored as a PNG file under the name ‘test_i.png’ where i varies from zero to n-1 where ‘n’ is the total number of images generated. Every image is an inverted cartesian plane with origin at the centre of the image and y-coordinate increasing in the downward direction.
- It also outputs the signal to noise ratio of the images generated.
- The function has a few global variables for further use by other programs.





test_0	5/1/2018 9:25 AM	PNG File	6 KB
test_1	5/1/2018 9:25 AM	PNG File	6 KB
test_2	5/1/2018 9:25 AM	PNG File	6 KB
test_3	5/1/2018 9:25 AM	PNG File	6 KB
test_4	5/1/2018 9:25 AM	PNG File	6 KB
test_5	5/1/2018 9:25 AM	PNG File	6 KB
test_6	5/1/2018 9:25 AM	PNG File	6 KB
test_7	5/1/2018 9:25 AM	PNG File	6 KB
test_8	5/1/2018 9:25 AM	PNG File	6 KB
test_9	5/1/2018 9:25 AM	PNG File	6 KB
test_10	5/1/2018 9:25 AM	PNG File	6 KB
test_11	5/1/2018 9:25 AM	PNG File	6 KB
test_12	5/1/2018 9:25 AM	PNG File	6 KB
test_13	5/1/2018 9:25 AM	PNG File	6 KB
test_14	5/1/2018 9:25 AM	PNG File	6 KB
test_15	5/1/2018 9:25 AM	PNG File	6 KB
test_16	5/1/2018 9:29 AM	PNG File	6 KB
test_17	5/1/2018 9:29 AM	PNG File	6 KB
test_18	5/1/2018 9:29 AM	PNG File	6 KB
test_19	5/1/2018 9:29 AM	PNG File	6 KB
test_20	5/1/2018 9:29 AM	PNG File	6 KB
test_21	5/1/2018 9:29 AM	PNG File	6 KB
test_22	5/1/2018 9:29 AM	PNG File	6 KB

A total of 30 images are generated starting from ‘test_0.png’ to ‘test_29.png’.

Figure: *test_0.png*

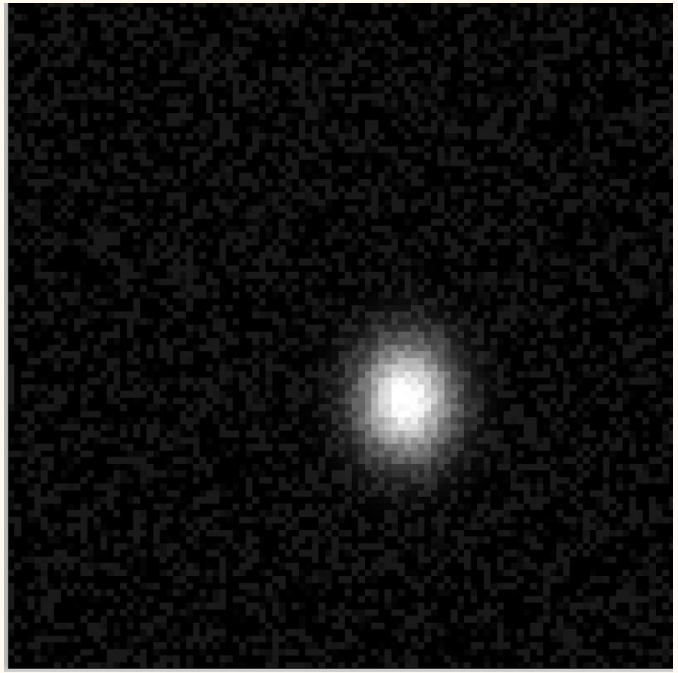


Figure: *test_29.png*

Variance of the noise here is 1.

Image Display

Functions:

1. Displayimg()
2. img_coll()
3. streak()

1. Displayimg(): This function generates a mesh diagram of the target at various instances during the traversal.

2. img_coll(): This function displays the generated images in a rectangular montage.

3. streak(): This function creates a streak to depict the traversal of the target.

Calling the functions

Function Definitions: Displayimg(file_path), img_coll(file_path), streak(file_path)

All the three functions take in the absolute path of the folder in which the images are generated and generate their respective outputs.

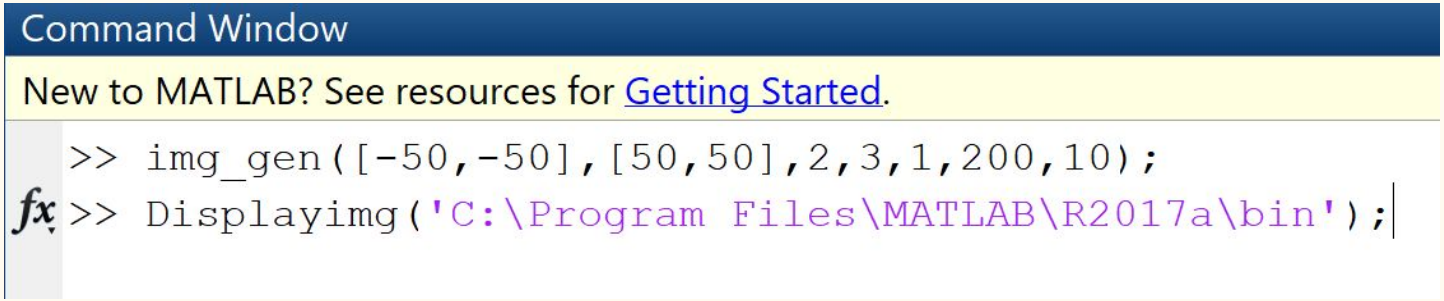


Figure: *Calling Displayimg()*

Outputs

Displayimg(): This function generates a surface diagram of the target at various instances during the traversal. The surface diagram consists of peaks which represents the target. The output is three mesh diagrams, one, which shows the complete traversal of the peak i.e. target, two, which plots the position of target in every fourth image when there are large number of images and three which shows the start and end points of the target.

Img_coll():This function produces a collage of the images generated i.e. every image generated is put side by side to visualize the trajectory of the target.

Streak(): This function creates an image which depicts the path traversed by the target.

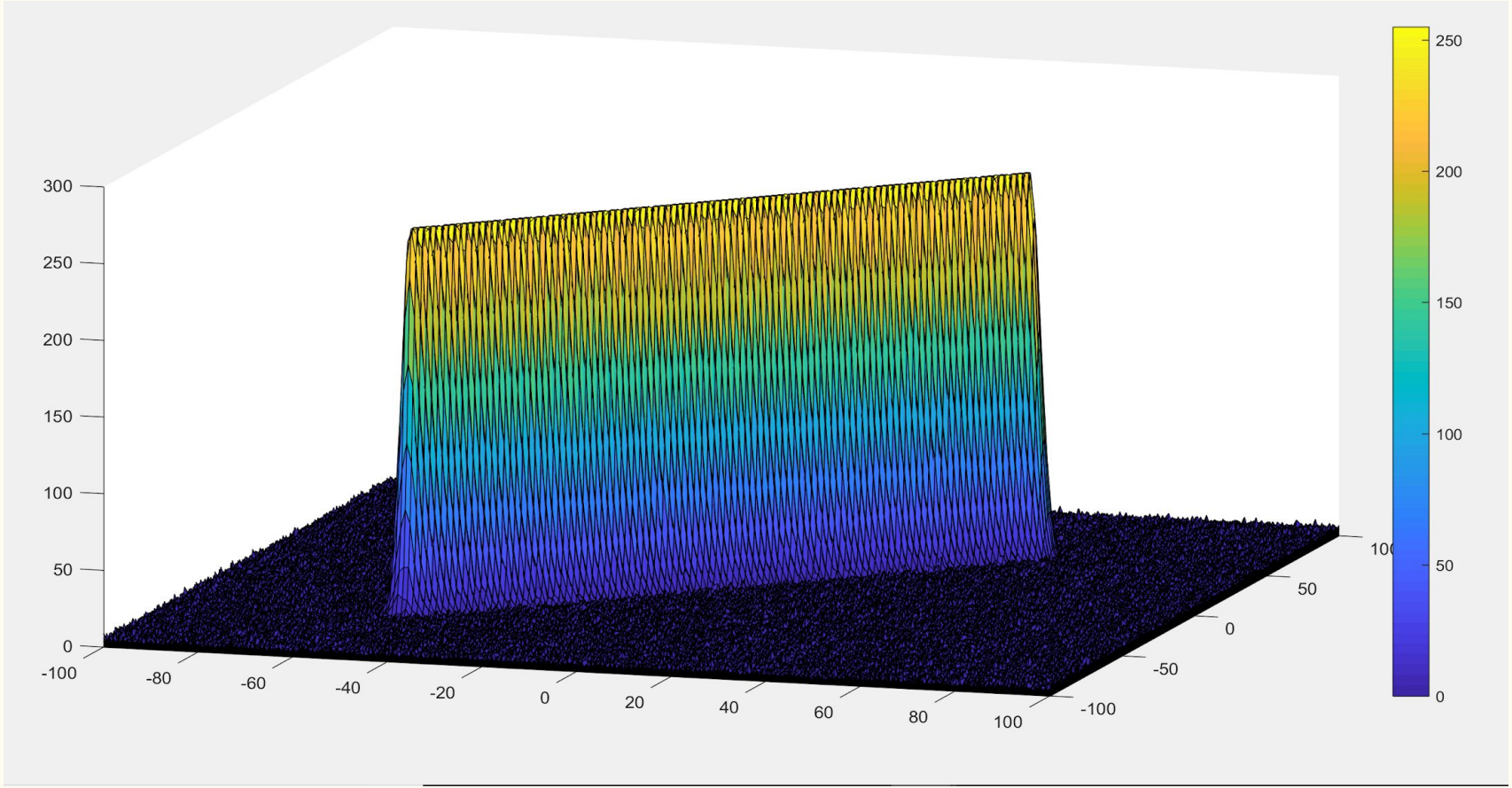
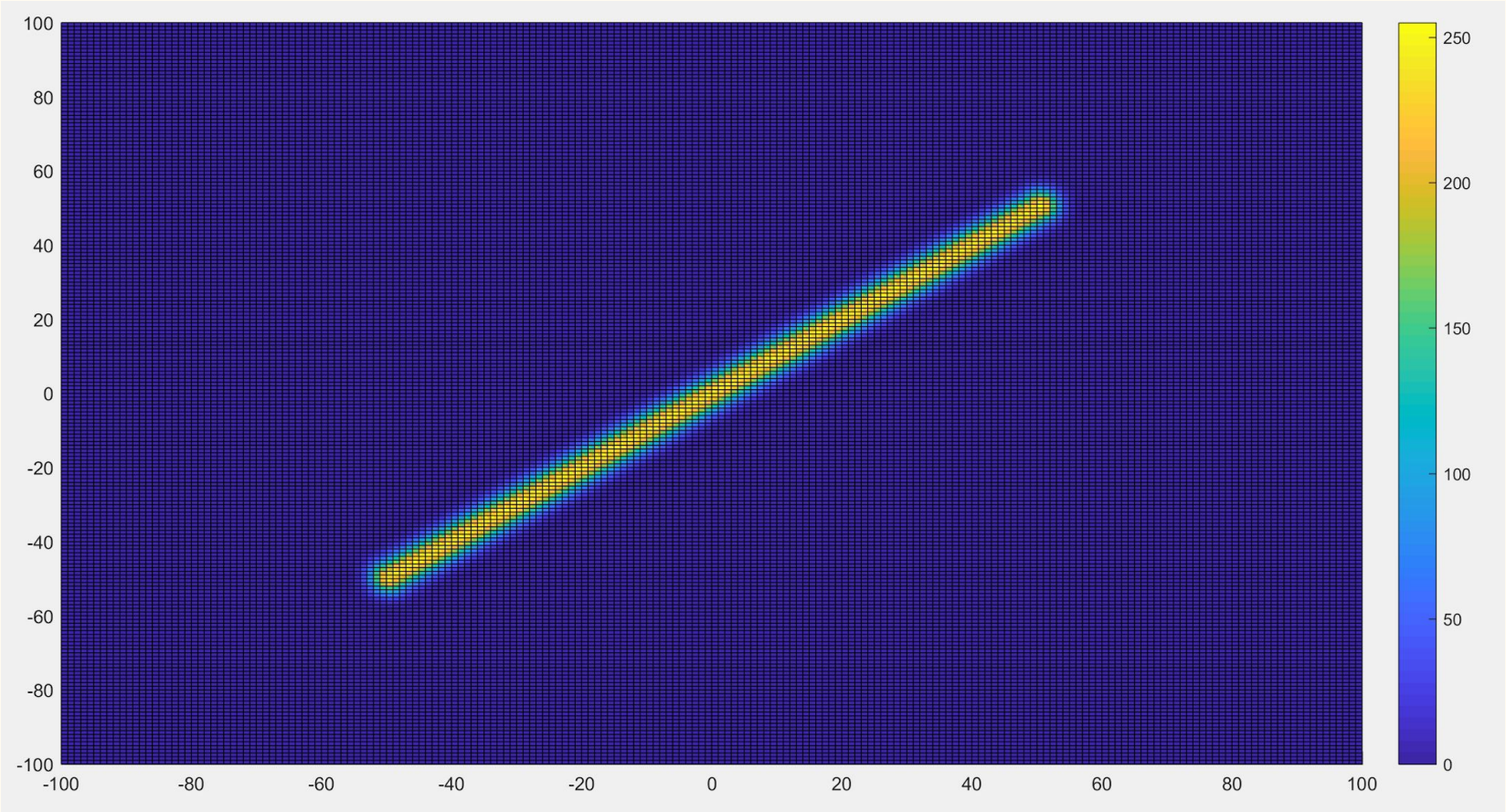


Figure: *Output of Displayimg()*

All the images generated are used to graph the surface plot so as to visualise the traversal.



When you rotate the figure using MATLAB figure rotate tool one can see the path followed by the target.

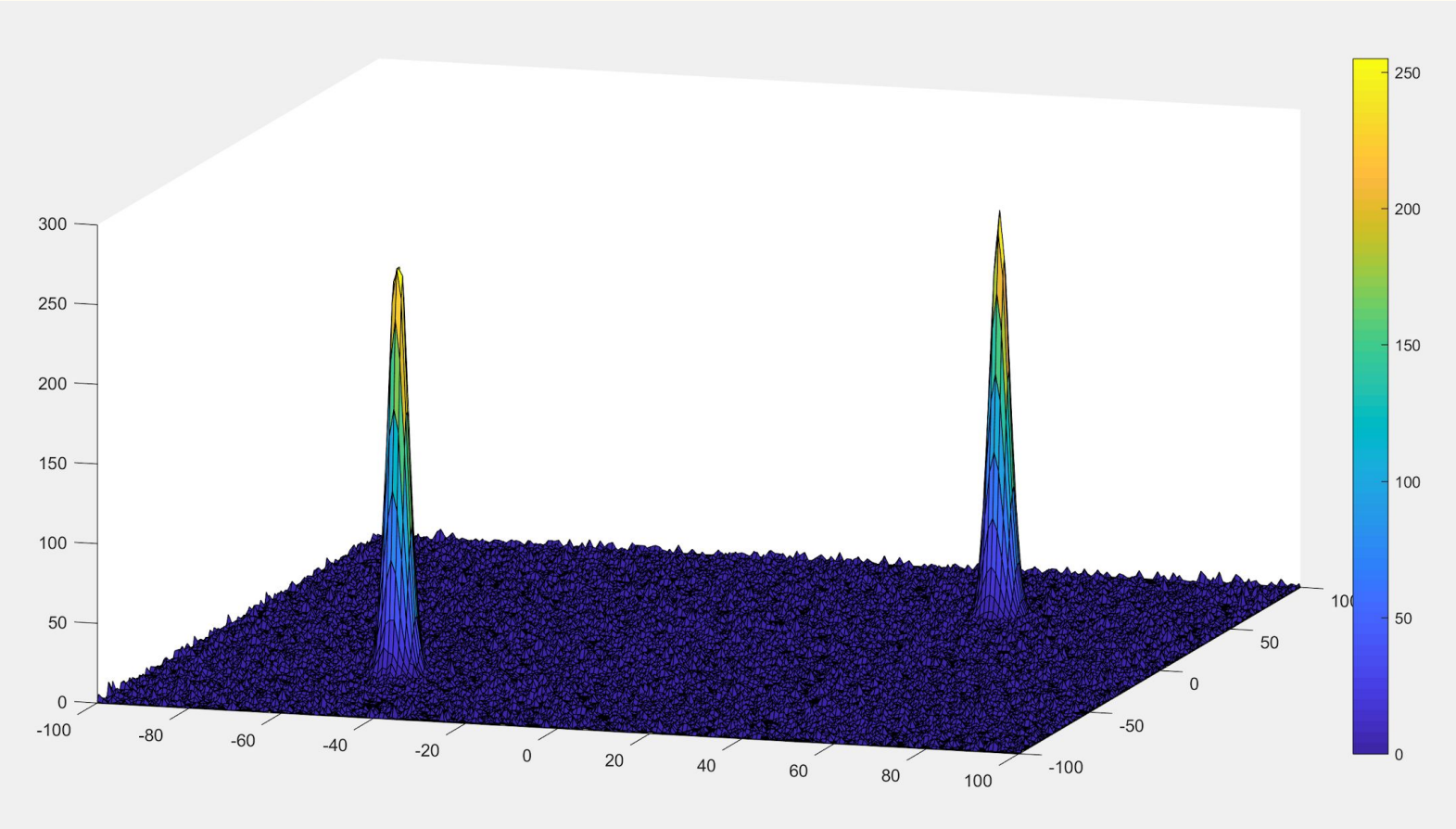


Figure: *Output of Displayimg()*

This output shows the start and endpoints of the target.

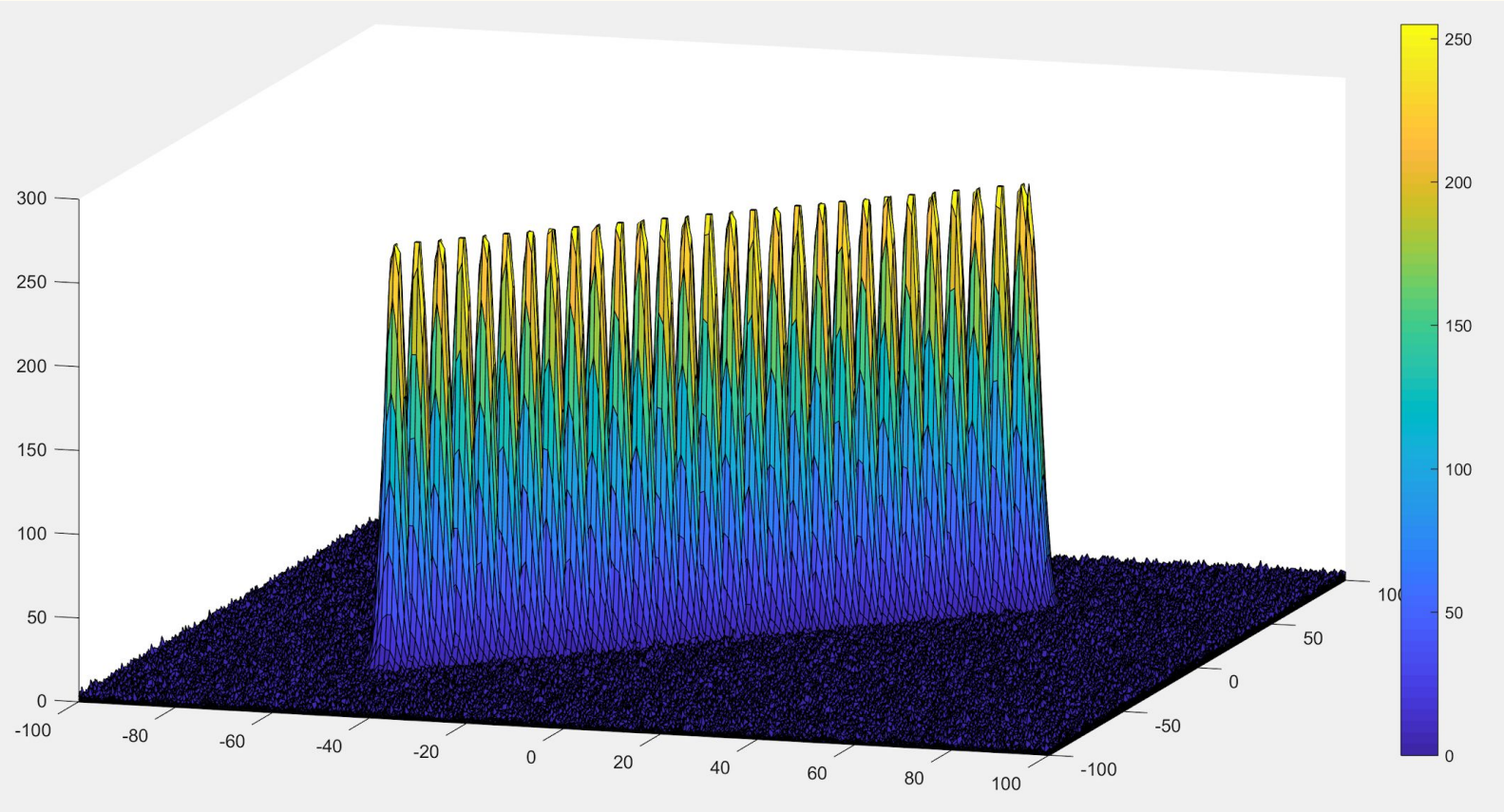


Figure: *Output of Displayimg()*

Here every fourth image is taken into account to generate the surface plots of the target at various instants.

Input:

Command Window

New to MATLAB? See resources for Getting Started.

```
>> img_gen([-5,-5],[5,5],2,3,1,100,10);
>> img_coll('C:\Program Files\MATLAB\R2017a\bin')
fx >>
```

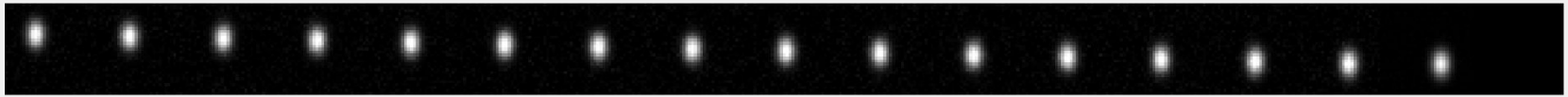


Figure: *Output of img_coll() function.*

```
Command Window
New to MATLAB? See resources for Getting Started.
>> img_gen([-10,-10],[10,10],2,3,1,100,10);
>> streak('C:\Program Files\MATLAB\R2017a\bin')
>>
```

Figure: *Calling streak()*

Figure: *Output of streak().*

Video generation

Function: vid_gen()

The vid_gen() generates a video of the traversal of the target, by using the images generated by the img_gen() function.

Calling the function

The vid_gen function requires the absolute path of the folder in which the images are generated.

Output

The output is a video of the target trajectory named “target.avi”.

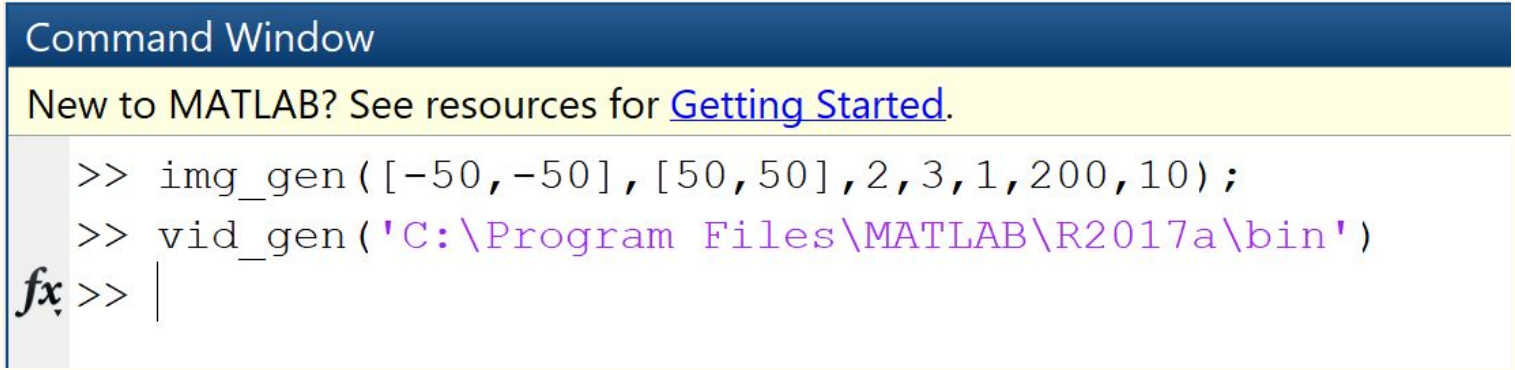


Figure: *Calling the vid_gen() function*

Citations

1. ^ Yaakov Bar-Shalom, Peter K. Willett and Xin Tian(2011). *Tracking and Data Fusion: A Handbook of Algorithms*. YBS Publishing. p.1834.
2. ^ Yaakov Bar-Shalom, Peter K. Willett and Xin Tian(2011). *Op. cit.*, p.1848.
3. ^ Yaakov Bar-Shalom, Peter K. Willett and Xin Tian(2011). *Op. cit.*, p.1836.
4. ^ Yaakov Bar-Shalom, Peter K. Willett and Xin Tian(2011). *Op. cit.*, p.1824.