**Planning for my final report**

1. **Abstract**
2. **Introduction**
   1. **Motivation:** why we use surrogate model & problems statement
   2. **Background:** surrogate models and main types
3. **Methodology**
   1. **Gaussian Process Regression** 
      1. **Main Principle:** explain the principle of GPR
      2. **Kernels functions:** introduce the common-used co-variances functions
   2. **Error Analysis Methods:** RMSE and R^2
4. **Results**
   1. **Maximum Principle Stress Prediction**
      1. **7 Testing Points Methods:** 7 random points are selected as testing data, leaving the remaining 42 as training data.
      2. **Prediction in New Data:** 14 different load combination are randomly generated and the prediction of max stress is given by GPR.
      3. **Comparison between Different Kernel functions:** 3 different kernel functions (covariance functions) and their combinations are used to give the prediction for the same testing data. Their prediction accuracy are compared.
   2. **Maximum Principle Stress Position Prediction**
      1. **Train X and Y coordinates** **separately:** the x and y coordinates of max stress are trained separately.

**4.2.2 Prediction Max Stress Position in Polar Coordinate:**

max stress occurs in the inner cycle of the model. So equation (x-a)²+(y-b)²=r² should be satisfied. Therefor the training of x y coordinate can be simplified into the training of angle from reference direction(with the distance r) in polar coodinate.

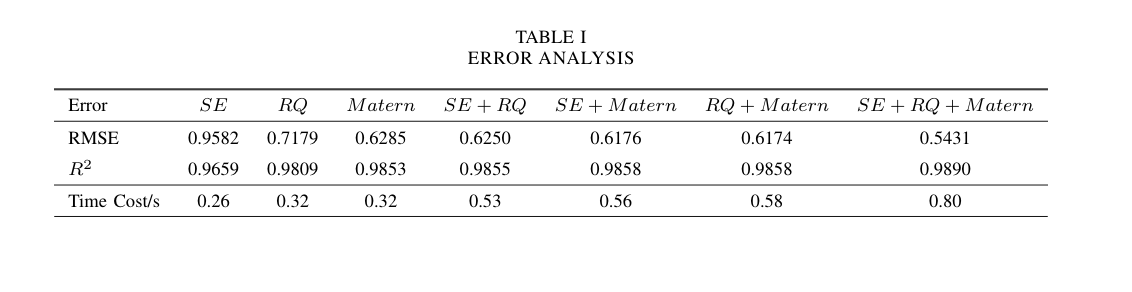
**4.2.3 Prediction Max Stress Position in Polar Coordinate with 121 Training Samples:** more training samples are used and prediction accuracy are improved.

1. **Conclusion**
2. **Acknowledgment**
3. **Reference**

**New Results**

**4.1.3 Comparison between Different Kernel functions**

3 different kernel functions (covariance functions) and their combinations are used to give the prediction for the same testing data. The mean function is always empty. RMSE, R^2 error and the time to running the code are given in table 1.

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It is not hard to find that the prediction accuracy increase with more kernels combined. But it costs more time.

**4.2.1 Train X and Y coordinates** **separately:**

X and Y coordinates are first trained separately with 49 training data.

a) The fitting line of x coordinate

b) The fitting line of y coordinate

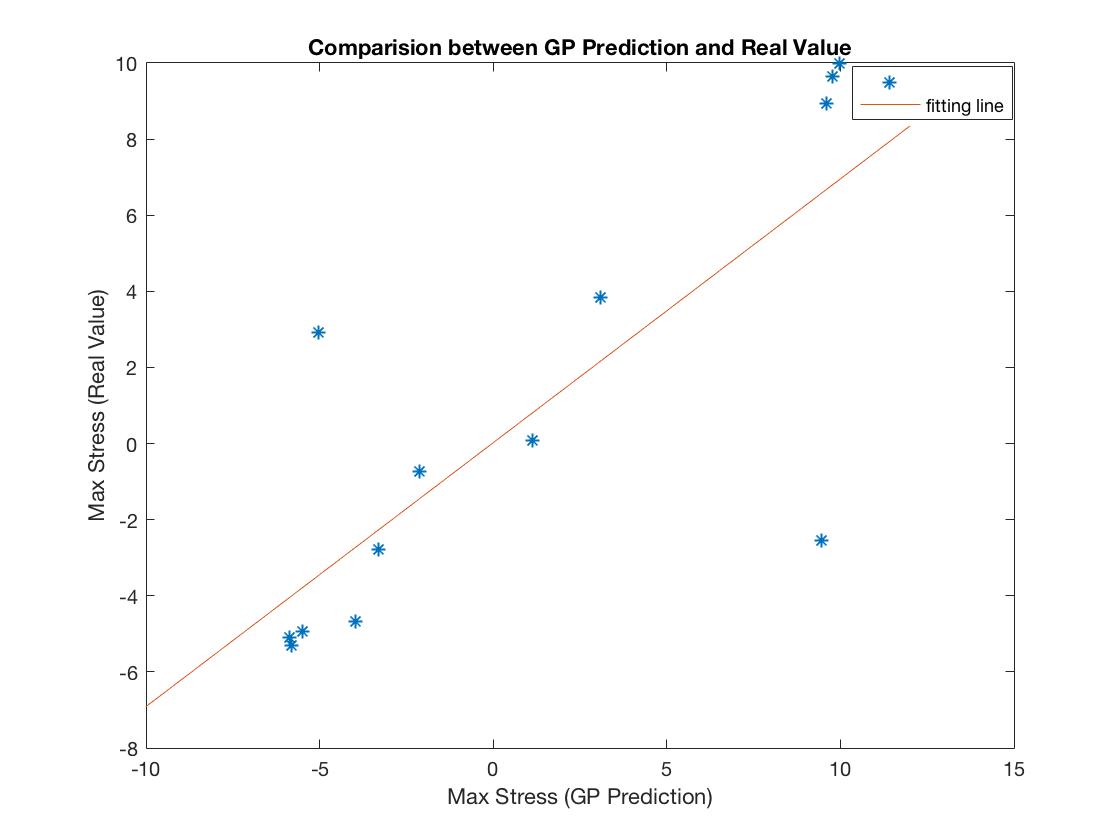
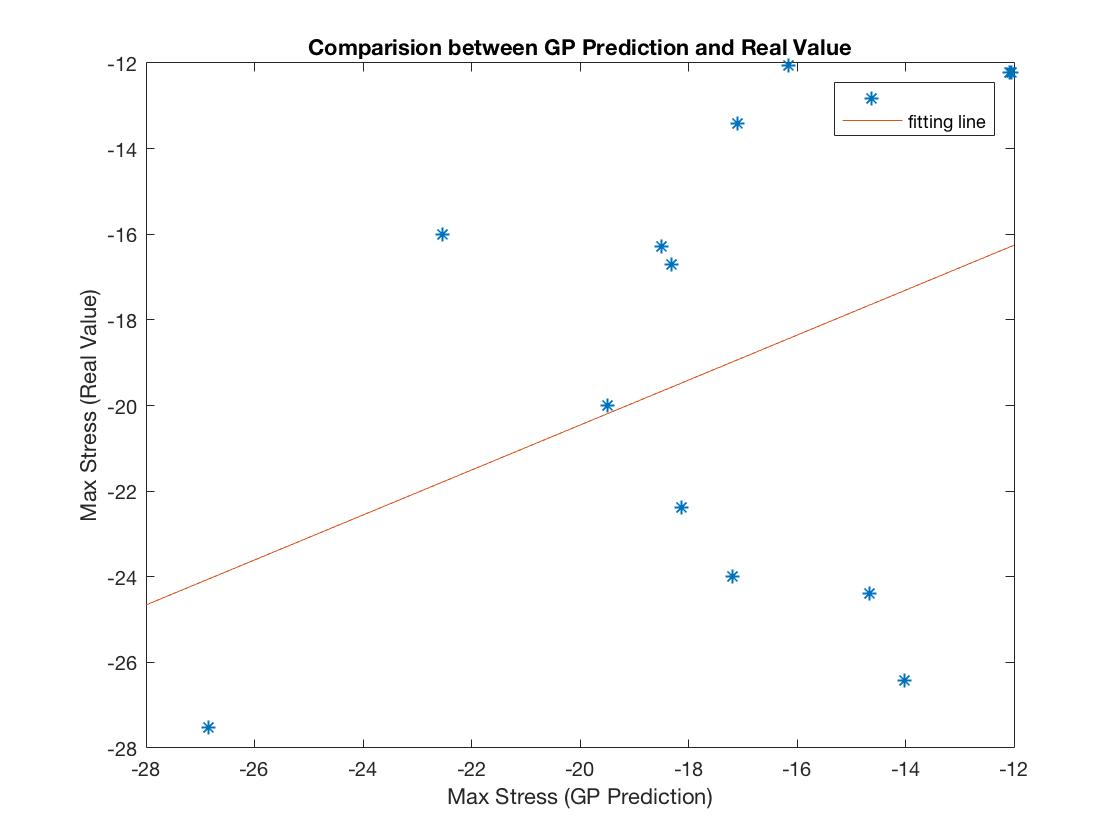


Figure 1: Fitted line of x and y coordinate training with 49 samples

RMSE of y coordination prediction is 5.1811 and for y is 3.6515.

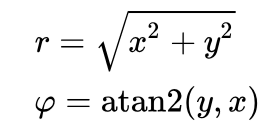
The fitted line of x coordinate is: y=2.5x +27.8.

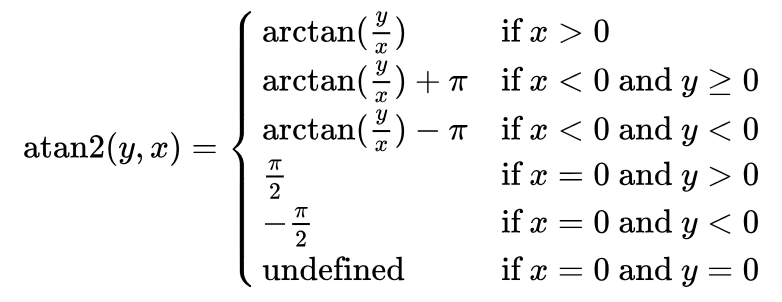
The fitted line of y coordinate is: y=0.93x–0.74

**4.2.2 Prediction Max Stress Position in Polar Coordinate:**

max stress occurs in the inner cycle of the model. So equation (x-a)²+(y-b)²=r² should be satisfied. Therefor the training of x y coordinate can be simplified into the training of angle from reference direction (with the distance r) in polar coordinate. Now the problems are simplified because the 2 outputs problems(x,y) becomes single output problem(angle).

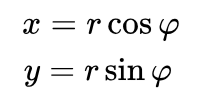
**1.** I transfer coordinate of max stress from Cartesian coordinates into Polar coordinate:





Here **r** is always the radius of inner cycle. So the angle are the only training output.

**2.**The angle are used to do the training. After training, I transfer the prediction angle into x, y coordinates:



and compared with the real x-y coordinates:

a) The fitting line of x coordinate

b) The fitting line of y coordinate

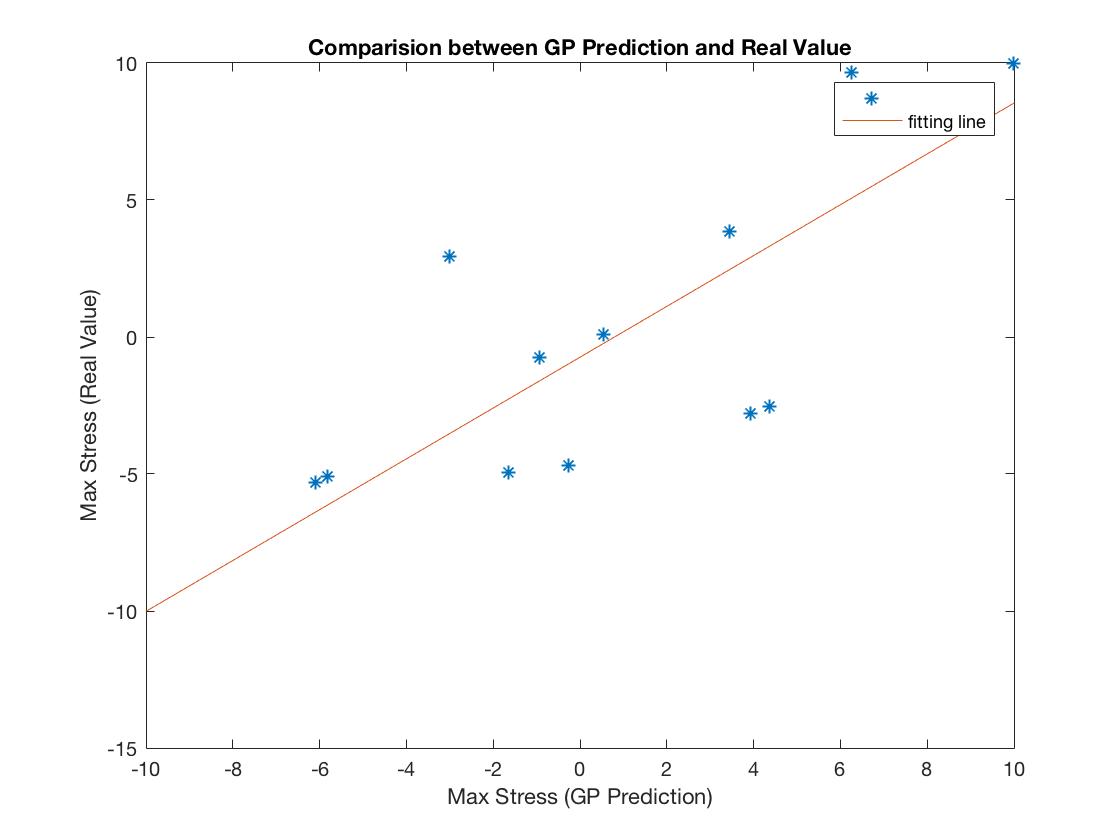
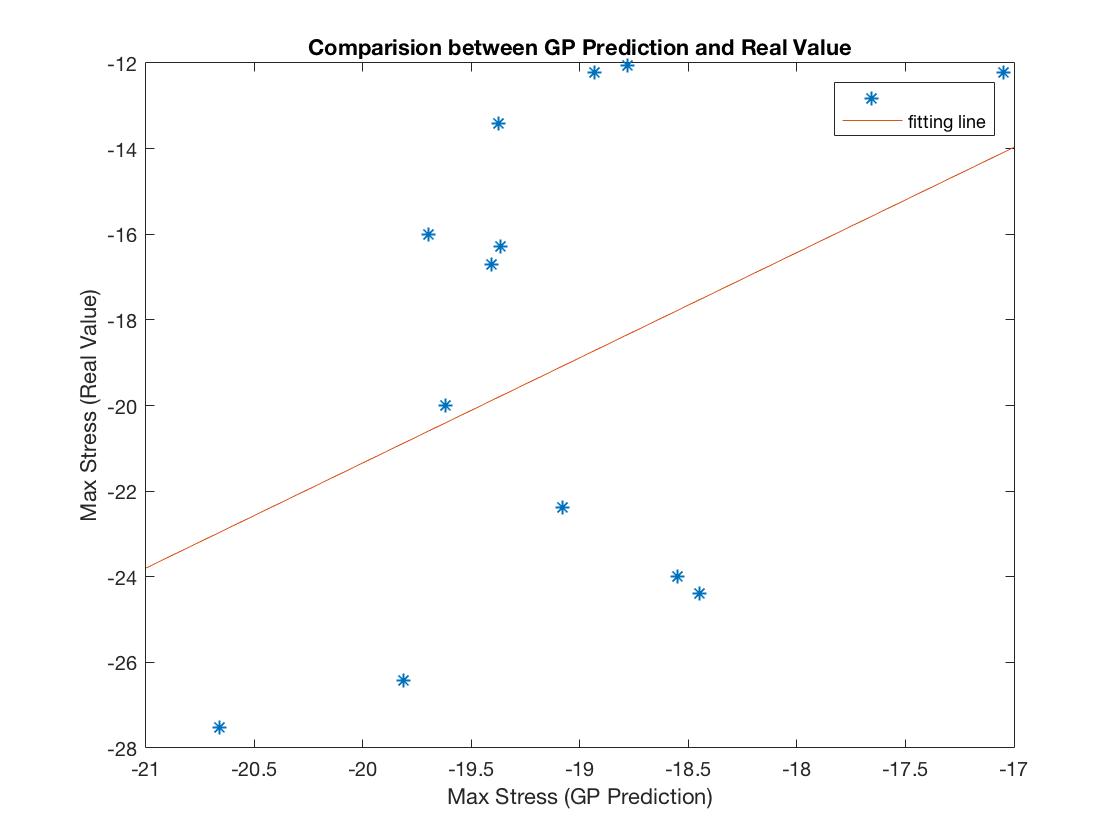


Figure 2: Fitted line of polar coordinate training with 49 samples

RMSE of y coordination prediction is 5.611 and for y is 3.905.

The fitted line of x coordinate is: y=0.53 x – 9.95.

The fitted line of y coordinate is: y=0.69x – 0.022

Although the problem is simplified into a single output problem, the prediction results have not been improved.

**4.2.3 Prediction Max Stress Position in Polar Coordinate with 121 Training Samples**

121 training samples are used and the prediction accuracy are greatly improved.

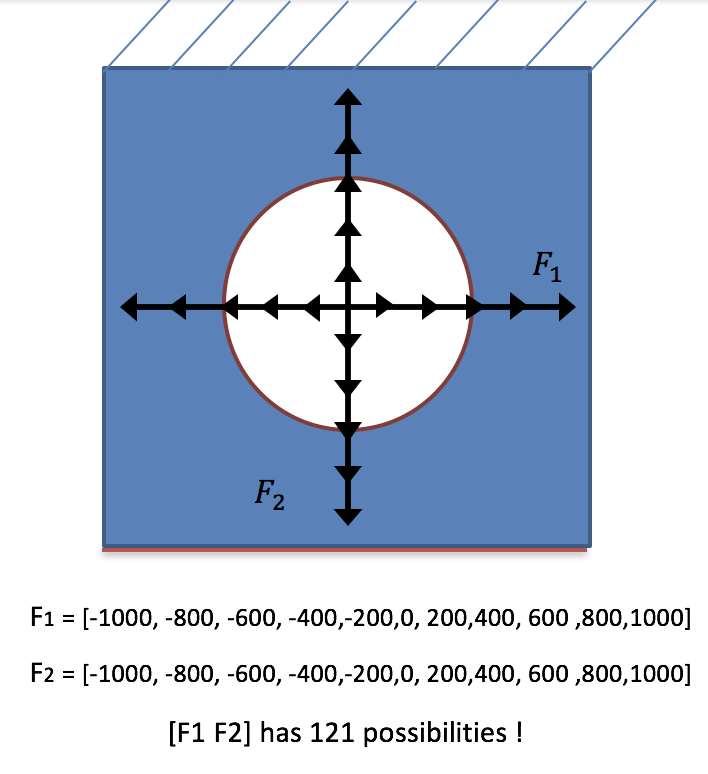
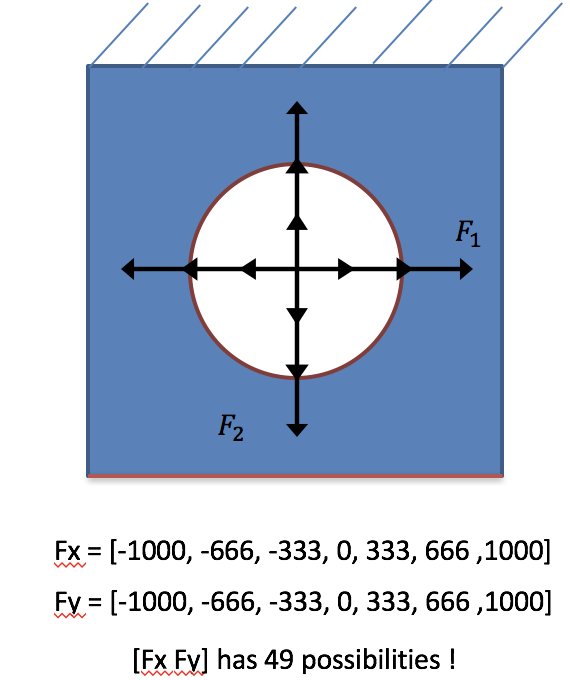
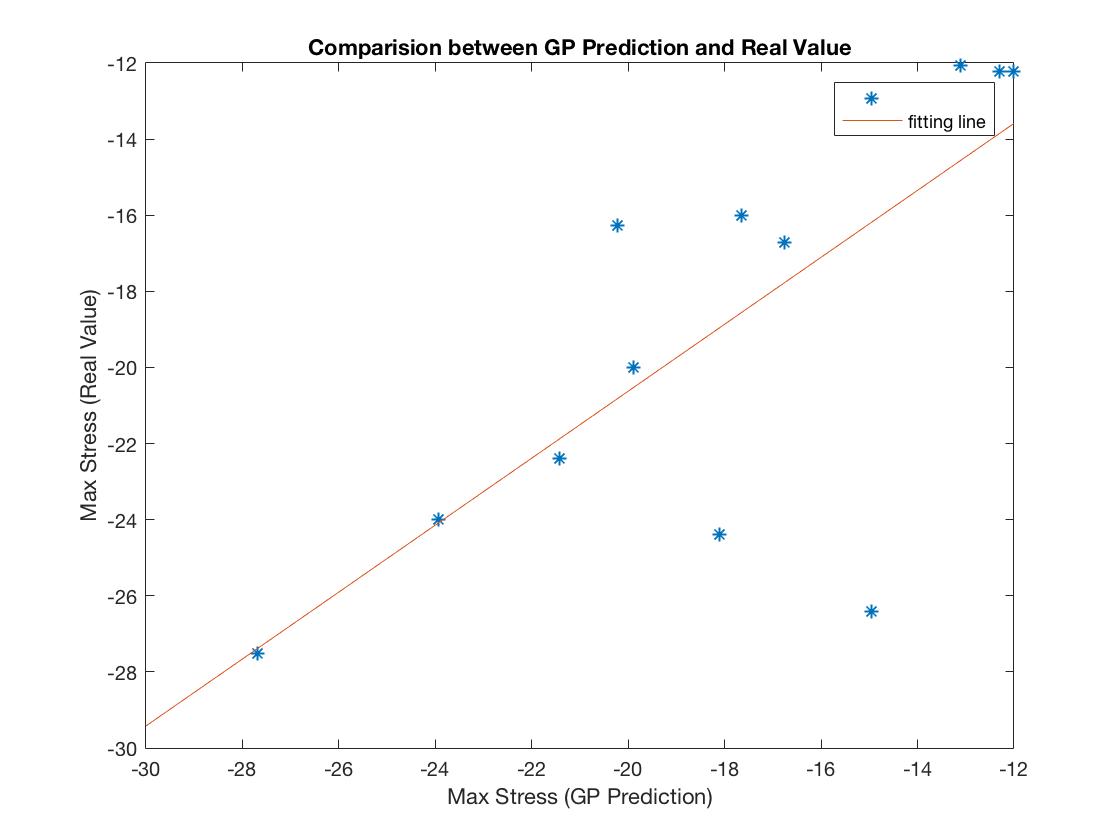


Figure 3: sampling

Figure 4: Fitted line of polar coordinate training with 121 samples

a) The fitting line of x coordinate

b) The fitting line of y coordinate



RMSE of y coordination prediction is 3.7 and for y is 3.0.

The fitted line of x coordinate is: y=0.88 x – 3.0.

The fitted line of y coordinate is: y=0.80x

**4.1.2 Prediction in New Data**

The fitted line of max stress is improved: y= 1.01x -0.41