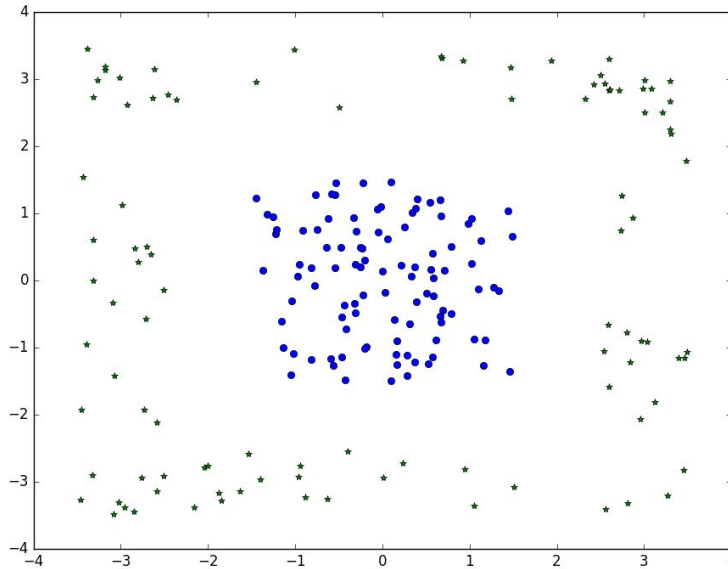


REPORT

1. Kernel Trick

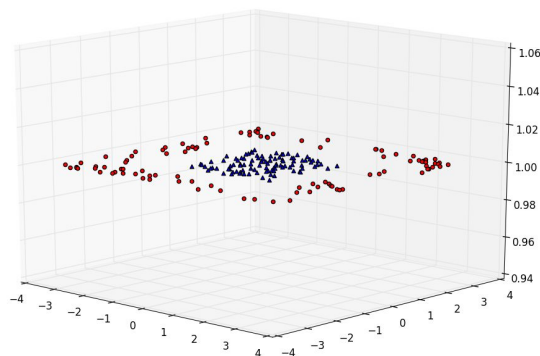
2D Visualization of Data



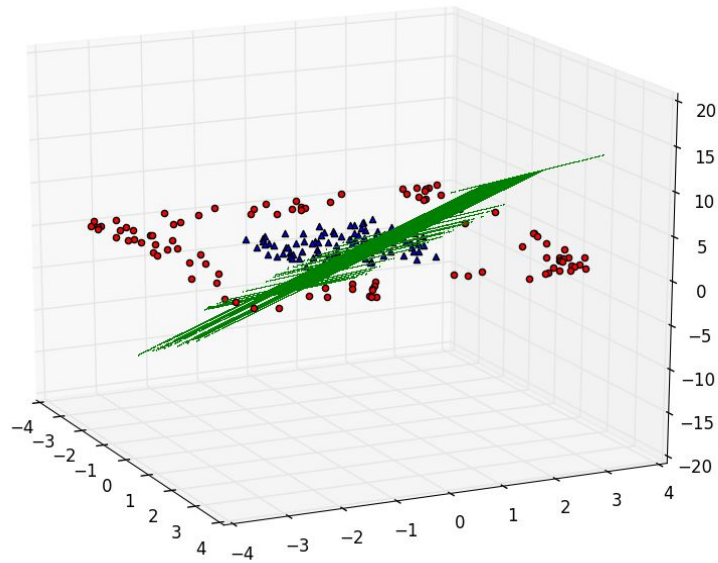
Clearly, the data is not linearly separable. We need to try different kernel functions to see which of them makes it so.

Kernel Functions

i. Kernel = 1



Data Visualization after applying kernel function

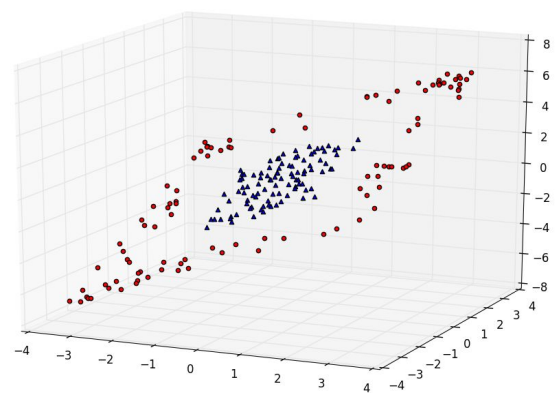


Trying to fit a Perceptron Model

Accuracy = 58 %

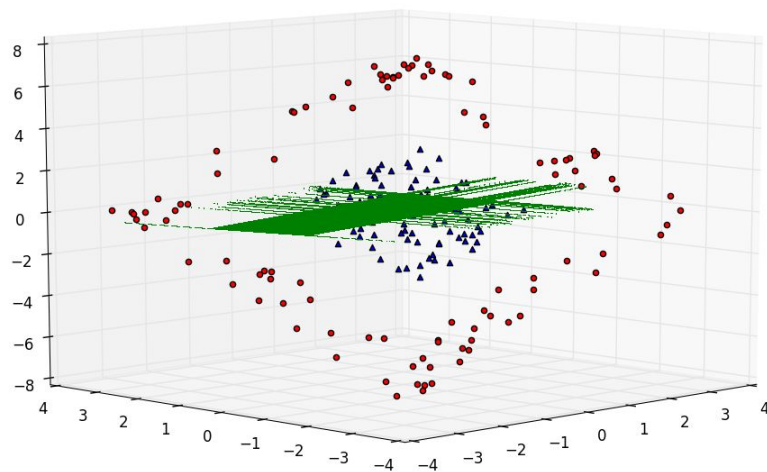
ii. Kernel = $x+y$

Data Visualization after applying kernel



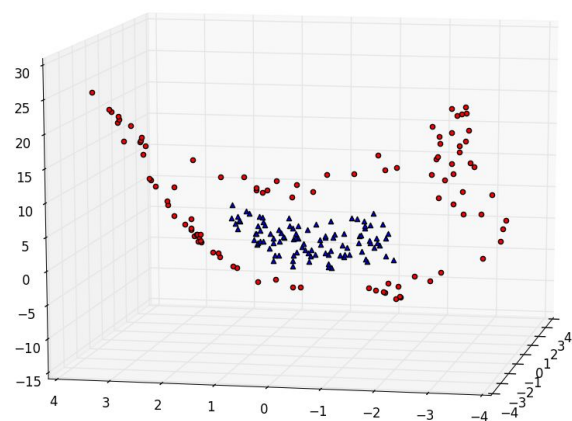
Trying to fit a
perceptron
model

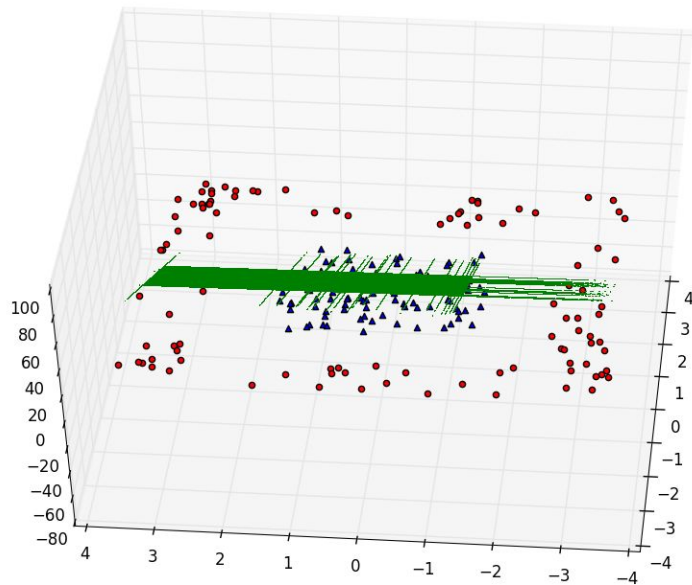
Accuracy=53%



iii. Kernel = $Y^2 - 4x$

Data visualization after
applying kernel



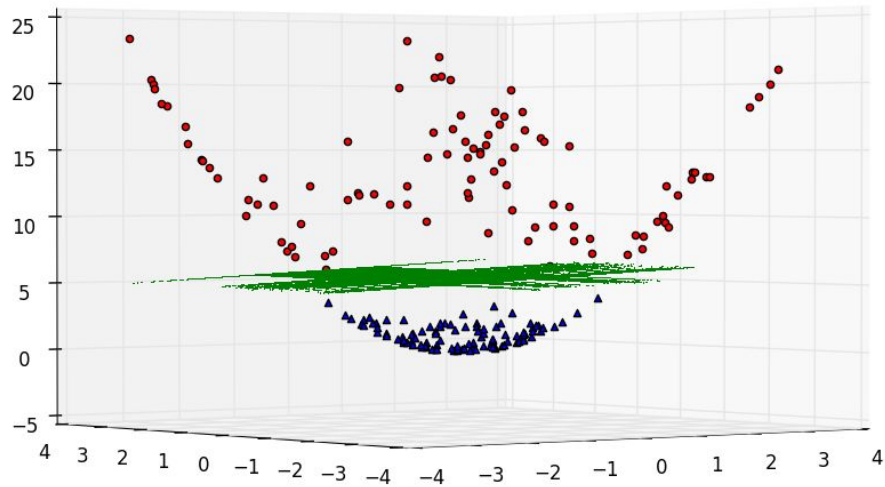


Trying to fit a Perceptron Model

Accuracy = 59 %

iv. Kernel = $x^2 + y^2$

**Data Visualization
after applying
kernel function.**



Trying to fit a Perceptron Model

Accuracy = 100 %

Conclusion

The Kernel Function that makes the data linearly separable is x^2+y^2 with accuracy **100%**.

Reasoning

As we can see in the 2D visualization that the data that there is a radial boundary that separates the two classes of data, i.e., the difference between the points of the two classes of data is the distance from the origin (0,0). This is captured perfectly by the kernel function x^2+y^2 .

2. LETTER CLASSIFICATION

In this question, I ran my code for the following combinations : -

i. Kernel = “poly” with degrees [1,2,3] , “linear”, “rbf”

ii. C = [0.1, 1, 10, 100]

iii. gamma = [0.1, 1, 10, 100]

Statistics

kernel: poly C: 0.1 gamma: 0.1 degree: 2

Accuracy : 0.7989

Precision : 0.843495532676

Recall : 0.796604809931

F1-score : 0.807089784113

kernel: poly C: 0.1 gamma: 0.1 degree: 3

Accuracy : 0.8238

Precision : 0.890873055634

Recall : 0.822315249809

F1-score : 0.842124150609

kernel: poly C: 0.1 gamma: 0.1 degree: 4

Accuracy : 0.7626

Precision : 0.899071680765

Recall : 0.761138017997

F1-score : 0.804777603348

kernel: poly C: 0.1 gamma: 1 degree: 2

Accuracy : 0.9457

Precision : 0.946435088676

Recall : 0.94519589733

F1-score : 0.945262123234

kernel: poly C: 0.1 gamma: 1 degree: 3

Accuracy : 0.9495

Precision : 0.95032064793

Recall : 0.949184546607

F1-score : 0.949363038759

kernel: poly C: 0.1 gamma: 1 degree: 4

Accuracy : 0.9162

Precision : 0.918649849694

Recall : 0.915824710778
F1-score : 0.915938561397

kernel: poly C: 0.1 gamma: 10 degree: 2
Accuracy : 0.9393
Precision : 0.940224969263
Recall : 0.939046961008
F1-score : 0.939090606554

kernel: poly C: 0.1 gamma: 10 degree: 3
Accuracy : 0.9405
Precision : 0.94120934395
Recall : 0.940113881684
F1-score : 0.940153285151

kernel: poly C: 0.1 gamma: 10 degree: 4
Accuracy : 0.9107
Precision : 0.913827682973
Recall : 0.910242189268
F1-score : 0.910421115276

kernel: poly C: 0.1 gamma: 100 degree: 2
Accuracy : 0.9426
Precision : 0.943578777297
Recall : 0.942261530406
F1-score : 0.942325645796

kernel: poly C: 0.1 gamma: 100 degree: 3
Accuracy : 0.9431
Precision : 0.944347358211
Recall : 0.94271094484
F1-score : 0.942946153674

kernel: poly C: 0.1 gamma: 100 degree: 4
Accuracy : 0.9157
Precision : 0.917828721448
Recall : 0.915436792903
F1-score : 0.915310903993

kernel: poly C: 1 gamma: 0.1 degree: 2
Accuracy : 0.9159
Precision : 0.919491700199
Recall : 0.915094012432
F1-score : 0.915567468922

kernel: poly C: 1 gamma: 0.1 degree: 3

Accuracy : 0.9273
Precision : 0.934492583956
Recall : 0.926757316968
F1-score : 0.928533612631

kernel: poly C: 1 gamma: 0.1 degree: 4
Accuracy : 0.8899
Precision : 0.92264199818
Recall : 0.889081651342
F1-score : 0.898718569409

kernel: poly C: 1 gamma: 1 degree: 2
Accuracy : 0.9433
Precision : 0.944021821152
Recall : 0.94304364229
F1-score : 0.943075458487

kernel: poly C: 1 gamma: 1 degree: 3
Accuracy : 0.9487
Precision : 0.949620172891
Recall : 0.948471067247
F1-score : 0.948555078708

kernel: poly C: 1 gamma: 1 degree: 4
Accuracy : 0.9163
Precision : 0.918514085477
Recall : 0.916075334312
F1-score : 0.916023527976

kernel: poly C: 1 gamma: 10 degree: 2
Accuracy : 0.9424
Precision : 0.943108538633
Recall : 0.942037853022
F1-score : 0.942081451639

kernel: poly C: 1 gamma: 10 degree: 3
Accuracy : 0.9465
Precision : 0.947295848997
Recall : 0.946240146781
F1-score : 0.946323704163

kernel: poly C: 1 gamma: 10 degree: 4
Accuracy : 0.9142
Precision : 0.916207379972
Recall : 0.913902340922
F1-score : 0.913889143168

kernel: poly C: 1 gamma: 100 degree: 2
Accuracy : 0.9404
Precision : 0.94116601418
Recall : 0.940125394293
F1-score : 0.940163387045

kernel: poly C: 1 gamma: 100 degree: 3
Accuracy : 0.9423
Precision : 0.943206725334
Recall : 0.941965349356
F1-score : 0.942091480878

kernel: poly C: 1 gamma: 100 degree: 4
Accuracy : 0.9123
Precision : 0.9145353432
Recall : 0.912115269368
F1-score : 0.912176247349

kernel: poly C: 10 gamma: 0.1 degree: 2
Accuracy : 0.9477
Precision : 0.948419378331
Recall : 0.94734208706
F1-score : 0.947433270655

kernel: poly C: 10 gamma: 0.1 degree: 3
Accuracy : 0.9539
Precision : 0.954697313594
Recall : 0.953668998495
F1-score : 0.953828149501

kernel: poly C: 10 gamma: 0.1 degree: 4
Accuracy : 0.9253
Precision : 0.929353189008
Recall : 0.924860391689
F1-score : 0.925651458665

kernel: poly C: 10 gamma: 1 degree: 2
Accuracy : 0.9402
Precision : 0.941101409702
Recall : 0.939660724024
F1-score : 0.939834990917

kernel: poly C: 10 gamma: 1 degree: 3
Accuracy : 0.9478
Precision : 0.948383444444

Recall : 0.947620270438
F1-score : 0.947588943873

kernel: poly C: 10 gamma: 1 degree: 4
Accuracy : 0.9193
Precision : 0.921373524288
Recall : 0.918935704955
F1-score : 0.919102148149

kernel: poly C: 10 gamma: 10 degree: 2
Accuracy : 0.9405
Precision : 0.941399711413
Recall : 0.940213645665
F1-score : 0.940284768127

kernel: poly C: 10 gamma: 10 degree: 3
Accuracy : 0.9499
Precision : 0.950494969907
Recall : 0.949634560519
F1-score : 0.949654083837

kernel: poly C: 10 gamma: 10 degree: 4
Accuracy : 0.9098
Precision : 0.912667424426
Recall : 0.909606361007
F1-score : 0.909694043296

kernel: poly C: 10 gamma: 100 degree: 2
Accuracy : 0.9418
Precision : 0.942740791118
Recall : 0.941378628834
F1-score : 0.941545014281

kernel: poly C: 10 gamma: 100 degree: 3
Accuracy : 0.9409
Precision : 0.942242409883
Recall : 0.940615853235
F1-score : 0.940762714912

kernel: poly C: 10 gamma: 100 degree: 4
Accuracy : 0.9101
Precision : 0.912465522898
Recall : 0.909978332007
F1-score : 0.909806697765

kernel: poly C: 100 gamma: 0.1 degree: 2

Accuracy : 0.9432
Precision : 0.943793872559
Recall : 0.942783769151
F1-score : 0.942905197961

kernel: poly C: 100 gamma: 0.1 degree: 3
Accuracy : 0.9476
Precision : 0.948469456585
Recall : 0.947399727974
F1-score : 0.947481685455

kernel: poly C: 100 gamma: 0.1 degree: 4
Accuracy : 0.9132
Precision : 0.915497405768
Recall : 0.912757465468
F1-score : 0.912900130673

kernel: poly C: 100 gamma: 1 degree: 2
Accuracy : 0.9442
Precision : 0.94472340576
Recall : 0.943823057861
F1-score : 0.943845730778

kernel: poly C: 100 gamma: 1 degree: 3
Accuracy : 0.946
Precision : 0.946591080524
Recall : 0.945681918805
F1-score : 0.945780428635

kernel: poly C: 100 gamma: 1 degree: 4
Accuracy : 0.9123
Precision : 0.914729082546
Recall : 0.912126637371
F1-score : 0.912254463262

kernel: poly C: 100 gamma: 10 degree: 2
Accuracy : 0.9439
Precision : 0.944301107325
Recall : 0.943524549969
F1-score : 0.943510629584

kernel: poly C: 100 gamma: 10 degree: 3
Accuracy : 0.9383
Precision : 0.93910557531
Recall : 0.937889127184
F1-score : 0.938044051207

kernel: poly C: 100 gamma: 10 degree: 4
Accuracy : 0.9113
Precision : 0.913363643556
Recall : 0.910985250183
F1-score : 0.910914878017

kernel: poly C: 100 gamma: 100 degree: 2
Accuracy : 0.9453
Precision : 0.946161336259
Recall : 0.94496565477
F1-score : 0.945088679483

kernel: poly C: 100 gamma: 100 degree: 3
Accuracy : 0.9499
Precision : 0.950776931073
Recall : 0.949777969336
F1-score : 0.949829852705

kernel: poly C: 100 gamma: 100 degree: 4
Accuracy : 0.9116
Precision : 0.914231312805
Recall : 0.911367379565
F1-score : 0.911470024323

kernel: linear C: 0.1 gamma: 0.1
Accuracy : 0.8416
Precision : 0.845391510275
Recall : 0.839955510854
F1-score : 0.840535722127

kernel: linear C: 0.1 gamma: 1
Accuracy : 0.8407
Precision : 0.844888798174
Recall : 0.839205579306
F1-score : 0.84000010385

kernel: linear C: 0.1 gamma: 10
Accuracy : 0.8451
Precision : 0.849329517162
Recall : 0.843549816481
F1-score : 0.844002149136

kernel: linear C: 0.1 gamma: 100
Accuracy : 0.844
Precision : 0.847233546436

Recall : 0.842372071129
F1-score : 0.842625355243

kernel: linear C: 1 gamma: 0.1
Accuracy : 0.8547
Precision : 0.85739723072
Recall : 0.853384315671
F1-score : 0.853788799273

kernel: linear C: 1 gamma: 1
Accuracy : 0.8521
Precision : 0.854313558013
Recall : 0.850564685772
F1-score : 0.850947667501

kernel: linear C: 1 gamma: 10
Accuracy : 0.8515
Precision : 0.852720258269
Recall : 0.850057949587
F1-score : 0.850276474325

kernel: linear C: 1 gamma: 100
Accuracy : 0.852
Precision : 0.853969407561
Recall : 0.850444414325
F1-score : 0.850815003968

kernel: linear C: 10 gamma: 0.1
Accuracy : 0.8537
Precision : 0.855638871319
Recall : 0.852155419513
F1-score : 0.852390872277

kernel: linear C: 10 gamma: 1
Accuracy : 0.8505
Precision : 0.852887777916
Recall : 0.849020148717
F1-score : 0.849611783673

kernel: linear C: 10 gamma: 10
Accuracy : 0.8581
Precision : 0.860073849632
Recall : 0.856820695701
F1-score : 0.8570991038

kernel: linear C: 10 gamma: 100

Accuracy : 0.85
Precision : 0.851574134977
Recall : 0.848499631741
F1-score : 0.848935657974

kernel: linear C: 100 gamma: 0.1
Accuracy : 0.8495
Precision : 0.851636948255
Recall : 0.848106479289
F1-score : 0.848184913901

kernel: linear C: 100 gamma: 1
Accuracy : 0.8463
Precision : 0.848792333174
Recall : 0.844940043303
F1-score : 0.845005962567

kernel: linear C: 100 gamma: 10
Accuracy : 0.8524
Precision : 0.854388587899
Recall : 0.851024534052
F1-score : 0.851224162415

kernel: linear C: 100 gamma: 100
Accuracy : 0.8516
Precision : 0.85349165866
Recall : 0.850300239061
F1-score : 0.850501775421

kernel: rbf C: 0.1 gamma: 0.1
Accuracy : 0.8579
Precision : 0.869540195676
Recall : 0.856588258496
F1-score : 0.85876279654

kernel: rbf C: 0.1 gamma: 1
Accuracy : 0.6581
Precision : 0.93294530284
Recall : 0.654222217742
F1-score : 0.737066705053

kernel: rbf C: 0.1 gamma: 10
Accuracy : 0.0425
Precision : 0.040022352867
Recall : 0.0405405405405
F1-score : 0.00693007696583

kernel: rbf C: 0.1 gamma: 100
Accuracy : 0.0418
Precision : 0.0400212586554
Recall : 0.0398128898129
F1-score : 0.00560079876022

kernel: rbf C: 1 gamma: 0.1
Accuracy : 0.954
Precision : 0.955716412678
Recall : 0.95359990406
F1-score : 0.953973672845

kernel: rbf C: 1 gamma: 1
Accuracy : 0.9382
Precision : 0.950494424402
Recall : 0.937781578661
F1-score : 0.94139012527

kernel: rbf C: 1 gamma: 10
Accuracy : 0.2691
Precision : 0.96228187082
Recall : 0.266961389664
F1-score : 0.361663749417

kernel: rbf C: 1 gamma: 100
Accuracy : 0.1255
Precision : 0.955524510557
Recall : 0.124522963707
F1-score : 0.153940087314

kernel: rbf C: 10 gamma: 0.1
Accuracy : 0.9734
Precision : 0.973694438841
Recall : 0.973181713433
F1-score : 0.973232809864

kernel: rbf C: 10 gamma: 1
Accuracy : 0.9442
Precision : 0.954062171545
Recall : 0.943830529297
F1-score : 0.946709694499

kernel: rbf C: 10 gamma: 10
Accuracy : 0.3027
Precision : 0.960904098359

Recall : 0.300540798004
F1-score : 0.406216292598

kernel: rbf C: 10 gamma: 100
Accuracy : 0.1281
Precision : 0.932448297495
Recall : 0.127252237384
F1-score : 0.157315634449

kernel: rbf C: 100 gamma: 0.1
Accuracy : 0.9705
Precision : 0.970832046687
Recall : 0.970244921474
F1-score : 0.97027924381

kernel: rbf C: 100 gamma: 1
Accuracy : 0.9354
Precision : 0.948514426737
Recall : 0.935068055086
F1-score : 0.938899062159

kernel: rbf C: 100 gamma: 10
Accuracy : 0.2995
Precision : 0.962464933073
Recall : 0.297639231097
F1-score : 0.403491965157

kernel: rbf C: 100 gamma: 100
Accuracy : 0.1241
Precision : 0.963202175213
Recall : 0.123432237041
F1-score : 0.15210660218

The maximum accuracy is achieved when kernel is **rbf**, C is **100** and gamma is **0.1**.

Maximum Accuracy: 97.05 %
Maximum Precision: 0.970832046687
Maximum Recall: 0.970244921474
Maximum F1: 0.97027924381

```
kernel: rbf C: 100 gamma: 0.1
Accuracy : 0.9715
Precision : 0.971842119865 Recall : 0.971372532999
F1-score : 0.971423016609
```