数据驱动测试报告

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# 1 实验内容

## *1.1 要求*

- 设计机器学习算法，利用NASA数据集和CK数据集进行软件缺陷预测；
- 利用10%，20%及30%的随机样本数据进行训练，使用剩余数据进行测试；
- 统计在两个数据集上的测试结果。

## *1.2 完成内容*

- 调用库，评估现有分类器的效果
  - 如 `MLPClassifier`、`DecisionTreeClassifier`、`RandomForestClassifier` 等等
  - 包含无监督、半监督、监督算法
- 复现相关论文算法
  - `ISDA` [1]

- `BaggingClassifierPU` [2]
- `JSFS` [3]

# 2 现有分类器评估

部分子数据集实验结果较差，在报告中忽略，具体结果可查看 `.\MultipleMethods\result` 目录。

## *2.1 AdaBoostClassifier*

AdaBoostClassifier (CK/ant1)

| | **10%** | **20%** | **30%** |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.4838709677419355 | 0.5483870967741935 | 0.559322033898305 |
| **recall** | 0.3614457831325301 | 0.4594594594594595 | 0.5076923076923077 |
| **pf** | 0.13675213675213677 | 0.1346153846153846 | 0.14285714285714285 |
| **F-measure** | 0.41379310344827586 | 0.5 | 0.532258064516129 |
| **accuracy** | 0.7318611987381703 | 0.7588652482269503 | 0.7651821862348178 |
| **AUC** | 0.6123468231901967 | 0.6624220374220374 | 0.6824175824175824 |

AdaBoostClassifier (CK/jedit4)

| | **10%** | **20%** | **30%** |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.4536082474226804 | 0.515625 | 0.4791666666666667 |
| **recall** | 0.6470588235294118 | 0.55 | 0.4339622641509434 |
| **pf** | 0.2548076923076923 | 0.16756756756756758 | 0.15432098765432098 |
| **F-measure** | 0.5333333333333333 | 0.5322580645161291 | 0.4554455445544555 |
| **accuracy** | 0.7210144927536232 | 0.763265306122449 | 0.7441860465116279 |
| **AUC** | 0.6961255656108598 | 0.6912162162162162 | 0.6398206382483113 |

AdaBoostClassifier (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.6451612903225806 | 0.6927710843373494 | 0.76 |
| **recall** | 0.546448087431694 | 0.7055214723926381 | 0.6643356643356644 |
| **pf** | 0.4435483870967742 | 0.4636363636363636 | 0.3125 |
| **F-measure** | 0.591715976331361 | 0.6990881458966565 | 0.7089552238805971 |
| **accuracy** | 0.5504885993485342 | 0.6373626373626373 | 0.6736401673640168 |
| **AUC** | 0.55144985016746 | 0.6209425543781372 | 0.6759178321678321 |

AdaBoostClassifier (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.5476190476190477 | 0.5492957746478874 | 0.5223880597014925 |
| **recall** | 0.2948717948717949 | 0.5652173913043478 | 0.5737704918032787 |
| **pf** | 0.12418300653594772 | 0.23529411764705882 | 0.2689075630252101 |
| **F-measure** | 0.3833333333333333 | 0.5571428571428572 | 0.5468749999999999 |
| **accuracy** | 0.6796536796536796 | 0.697560975609756 | 0.6777777777777778 |
| **AUC** | 0.5853443941679236 | 0.6649616368286444 | 0.6524314643890343 |

AdaBoostClassifier (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.5778894472361809 | 0.5813953488372093 | 0.6188925081433225 |
| **recall** | 0.6590257879656161 | 0.5645161290322581 | 0.7011070110701108 |
| **pf** | 0.448 | 0.3783783783783784 | 0.4006849315068493 |
| **F-measure** | 0.6157965194109772 | 0.5728314238952538 | 0.6574394463667821 |
| **accuracy** | 0.6035911602209945 | 0.5940902021772939 | 0.6483126110124334 |
| **AUC** | 0.605512893982808 | 0.5930688753269399 | 0.6502110397816308 |

AdaBoostClassifier (NASA/pc4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 128 | 257 | 386 |
| **defective train samples** | 17 | 35 | 53 |
| **precision** | 0.4125874125874126 | 0.475 | 0.59 |
| **recall** | 0.36875 | 0.4014084507042254 | 0.47580645161290325 |
| **pf** | 0.08408408408408409 | 0.07094594594594594 | 0.05276705276705277 |
| **F-measure** | 0.38943894389438943 | 0.4351145038167939 | 0.5267857142857142 |
| **accuracy** | 0.8403796376186368 | 0.8563106796116505 | 0.8823529411764706 |
| **AUC** | 0.642332957957958 | 0.6652312523791397 | 0.7115196994229253 |

AdaBoostClassifier (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.4470588235294118 | 0.5186567164179104 | 0.5358851674641149 |
| **recall** | 0.3584905660377358 | 0.3687002652519894 | 0.3393939393939394 |
| **pf** | 0.16845878136200718 | 0.13004032258064516 | 0.11175115207373272 |
| **F-measure** | 0.3979057591623037 | 0.43100775193798446 | 0.4155844155844156 |
| **accuracy** | 0.7012987012987013 | 0.7319211102994887 | 0.7370617696160268 |
| **AUC** | 0.5950158923378642 | 0.619329971335672 | 0.6138213936601032 |

## 2.2 CBLOF （无监督）

CBLOF (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5882352941176471 | 0.7021276595744681 | 0.5769230769230769 |
| **recall** | 0.3614457831325301 | 0.44594594594594594 | 0.23076923076923078 |
| **pf** | 0.08974358974358974 | 0.0673076923076923 | 0.06043956043956044 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **F-measure** | 0.4477611940298508 | 0.5454545454545454 | 0.3296703296703296 |
| **accuracy** | 0.7665615141955836 | 0.8049645390070922 | 0.7530364372469636 |
| **AUC** | 0.6358510966944703 | 0.6893191268191269 | 0.5851648351648352 |

CBLOF (CK/ivy2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 35 | 70 | 105 |
| **defective train samples** | 4 | 8 | 12 |
| **precision** | 0.33962264150943394 | 0.2926829268292683 | 0.3684210526315789 |
| **recall** | 0.5 | 0.375 | 0.5 |
| **pf** | 0.12455516014234876 | 0.116 | 0.1095890410958904 |
| **F-measure** | 0.4044943820224719 | 0.32876712328767116 | 0.4242424242424242 |
| **accuracy** | 0.832807570977918 | 0.8262411347517731 | 0.8461538461538461 |
| **AUC** | 0.6877224199288255 | 0.6295000000000001 | 0.6952054794520548 |

CBLOF (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.6296296296296297 | 0.6086956521739131 | 0.5263157894736842 |
| **recall** | 0.5 | 0.4666666666666667 | 0.18867924528301888 |
| **pf** | 0.09615384615384616 | 0.0972972972972973 | 0.05555555555555555 |
| **F-measure** | 0.5573770491803278 | 0.5283018867924527 | 0.27777777777777773 |
| **accuracy** | 0.8043478260869565 | 0.7959183673469388 | 0.7581395348837209 |
| **AUC** | 0.701923076923077 | 0.6846846846846847 | 0.5665618448637316 |

CBLOF (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.8243243243243243 | 0.84 | 0.8260869565217391 |
| **recall** | 0.3333333333333333 | 0.25766871165644173 | 0.13286713286713286 |
| **pf** | 0.10483870967741936 | 0.07272727272727272 | 0.041666666666666664 |
| **F-measure** | 0.47470817120622566 | 0.3943661971830986 | 0.22891566265060243 |
| **accuracy** | 0.5602605863192183 | 0.5274725274725275 | 0.46443514644351463 |
| **AUC** | 0.6142473118279569 | 0.5924707194645844 | 0.5456002331002332 |

CBLOF (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.5454545454545454 | 0.5789473684210527 | 0.6071428571428571 |
| **recall** | 0.6153846153846154 | 0.3188405797101449 | 0.2786885245901639 |
| **pf** | 0.26143790849673204 | 0.11764705882352941 | 0.09243697478991597 |
| **F-measure** | 0.5783132530120482 | 0.411214953271028 | 0.3820224719101123 |
| **accuracy** | 0.696969696969697 | 0.6926829268292682 | 0.6944444444444444 |
| **AUC** | 0.6769733534439417 | 0.6005967604433077 | 0.5931257749001241 |

CBLOF (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.4473684210526316 | 0.5769230769230769 | 0.5625 |
| **recall** | 0.85 | 0.4166666666666667 | 0.2903225806451613 |
| **pf** | 0.5753424657534246 | 0.16923076923076924 | 0.12280701754385964 |
| **F-measure** | 0.5862068965517242 | 0.48387096774193544 | 0.3829787234042554 |
| **accuracy** | 0.5752212389380531 | 0.6831683168316832 | 0.6704545454545454 |
| **AUC** | 0.6373287671232877 | 0.6237179487179487 | 0.5837577815506508 |

## 2.3 DecisionTreeClassifier

DecisionTreeClassifier (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5 | 0.4657534246575342 | 0.4915254237288136 |
| **recall** | 0.3373493975903614 | 0.4594594594594595 | 0.4461538461538462 |
| **pf** | 0.11965811965811966 | 0.1875 | 0.16483516483516483 |
| **F-measure** | 0.4028776978417266 | 0.4625850340136054 | 0.46774193548387105 |
| **accuracy** | 0.7381703470031545 | 0.7198581560283688 | 0.7327935222672065 |
| **AUC** | 0.6088456389661209 | 0.6359797297297297 | 0.6406593406593407 |

DecisionTreeClassifier (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.39344262295081966 | 0.4186046511627907 | 0.5357142857142857 |
| **recall** | 0.7058823529411765 | 0.6 | 0.5660377358490566 |
| **pf** | 0.3557692307692308 | 0.2702702702702703 | 0.16049382716049382 |
| **F-measure** | 0.5052631578947367 | 0.49315068493150693 | 0.5504587155963302 |
| **accuracy** | 0.6594202898550725 | 0.6979591836734694 | 0.772093023255814 |
| **AUC** | 0.6750565610859729 | 0.664864864864865 | 0.7027719543442813 |

DecisionTreeClassifier (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.624390243902439 | 0.7006369426751592 | 0.676056338028169 |
| **recall** | 0.6994535519125683 | 0.6748466257668712 | 0.6713286713286714 |
| **pf** | 0.6209677419354839 | 0.42727272727272725 | 0.4791666666666667 |
| **F-measure** | 0.6597938144329897 | 0.6875 | 0.6736842105263159 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **accuracy** | 0.5700325732899023 | 0.6336996336996337 | 0.6108786610878661 |
| **AUC** | 0.5392429049885422 | 0.623786949247072 | 0.5960810023310023 |

DecisionTreeClassifier (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.5263157894736842 | 0.4605263157894737 | 0.4418604651162791 |
| **recall** | 0.2564102564102564 | 0.5072463768115942 | 0.6229508196721312 |
| **pf** | 0.11764705882352941 | 0.3014705882352941 | 0.40336134453781514 |
| **F-measure** | 0.3448275862068965 | 0.48275862068965514 | 0.5170068027210885 |
| **accuracy** | 0.670995670995671 | 0.6341463414634146 | 0.6055555555555555 |
| **AUC** | 0.5693815987933634 | 0.60288789428815 | 0.609794737567158 |

DecisionTreeClassifier (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.56575682382134 | 0.5876923076923077 | 0.6212624584717608 |
| **recall** | 0.6532951289398281 | 0.6161290322580645 | 0.6900369003690037 |
| **pf** | 0.4666666666666667 | 0.4024024024024024 | 0.3904109589041096 |
| **F-measure** | 0.6063829787234042 | 0.6015748031496062 | 0.6538461538461537 |
| **accuracy** | 0.5911602209944752 | 0.6065318818040435 | 0.6483126110124334 |
| **AUC** | 0.5933142311365807 | 0.6068633149278311 | 0.649812970732447 |

DecisionTreeClassifier (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.5 | 0.32 | 0.45454545454545453 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **recall** | 0.475 | 0.2222222222222222 | 0.3225806451612903 |
| **pf** | 0.2602739726027397 | 0.26153846153846155 | 0.21052631578947367 |
| **F-measure** | 0.48717948717948717 | 0.26229508196721313 | 0.3773584905660377 |
| **accuracy** | 0.6460176991150443 | 0.5544554455445545 | 0.625 |
| **AUC** | 0.6073630136986302 | 0.4803418803418804 | 0.5560271646859083 |

DecisionTreeClassifier (NASA/pc4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 128 | 257 | 386 |
| **defective train samples** | 17 | 35 | 53 |
| **precision** | 0.452 | 0.41818181818181815 | 0.4921875 |
| **recall** | 0.70625 | 0.4859154929577465 | 0.5080645161290323 |
| **pf** | 0.13713713713713713 | 0.10810810810810811 | 0.08365508365508366 |
| **F-measure** | 0.551219512195122 | 0.4495114006514658 | 0.5 |
| **accuracy** | 0.8412424503882657 | 0.8359223300970874 | 0.8601553829078802 |
| **AUC** | 0.7845564314314314 | 0.6889036924248192 | 0.7122047162369742 |

DecisionTreeClassifier (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.3974025974025974 | 0.4447058823529412 | 0.42771084337349397 |
| **recall** | 0.3608490566037736 | 0.5013262599469496 | 0.4303030303030303 |
| **pf** | 0.2078853046594982 | 0.23790322580645162 | 0.21889400921658986 |
| **F-measure** | 0.3782447466007416 | 0.4713216957605985 | 0.42900302114803623 |
| **accuracy** | 0.6733766233766234 | 0.6902848794740687 | 0.6844741235392321 |
| **AUC** | 0.5764818759721377 | 0.631711517070249 | 0.6057045105432202 |

## 2.4 GaussianNB

GaussianNB (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5128205128205128 | 0.5540540540540541 | 0.5909090909090909 |
| **recall** | 0.4819277108433735 | 0.5540540540540541 | 0.6 |
| **pf** | 0.1623931623931624 | 0.15865384615384615 | 0.14835164835164835 |
| **F-measure** | 0.4968944099378882 | 0.5540540540540541 | 0.5954198473282443 |
| **accuracy** | 0.7444794952681388 | 0.7659574468085106 | 0.7854251012145749 |
| **AUC** | 0.6597672742251055 | 0.697700103950104 | 0.7258241758241758 |

GaussianNB (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.22797927461139897 | 0.5423728813559322 | 0.4925373134328358 |
| **recall** | 0.6470588235294118 | 0.5333333333333333 | 0.6226415094339622 |
| **pf** | 0.7163461538461539 | 0.14594594594594595 | 0.20987654320987653 |
| **F-measure** | 0.3371647509578544 | 0.5378151260504201 | 0.55 |
| **accuracy** | 0.37318840579710144 | 0.7755102040816326 | 0.7488372093023256 |
| **AUC** | 0.46535633484162897 | 0.6936936936936936 | 0.7063824831120429 |

GaussianNB (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.6632124352331606 | 0.8 | 0.7674418604651163 |
| **recall** | 0.6994535519125683 | 0.4171779141104294 | 0.46153846153846156 |
| **pf** | 0.5241935483870968 | 0.15454545454545454 | 0.20833333333333334 |
| **F-measure** | 0.6808510638297872 | 0.5483870967741935 | 0.5764192139737991 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **accuracy** | 0.6091205211726385 | 0.5897435897435898 | 0.5941422594142259 |
| **AUC** | 0.5876300017627357 | 0.6313162297824875 | 0.6266025641025642 |

GaussianNB (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.43902439024390244 | 0.5340909090909091 | 0.625 |
| **recall** | 0.23076923076923078 | 0.6811594202898551 | 0.6557377049180327 |
| **pf** | 0.1503267973856209 | 0.3014705882352941 | 0.20168067226890757 |
| **F-measure** | 0.3025210084033614 | 0.5987261146496815 | 0.64 |
| **accuracy** | 0.6406926406926406 | 0.6926829268292682 | 0.75 |
| **AUC** | 0.540221216691805 | 0.6898444160272804 | 0.7270285163245626 |

GaussianNB (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.5925925925925926 | 0.8 | 0.5652173913043478 |
| **recall** | 0.4 | 0.2222222222222222 | 0.41935483870967744 |
| **pf** | 0.1506849315068493 | 0.03076923076923077 | 0.17543859649122806 |
| **F-measure** | 0.4776119402985075 | 0.3478260869565218 | 0.4814814814814815 |
| **accuracy** | 0.6902654867256637 | 0.7029702970297029 | 0.6818181818181818 |
| **AUC** | 0.6246575342465753 | 0.5957264957264957 | 0.6219581211092248 |

GaussianNB (NASA/pc4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 128 | 257 | 386 |
| **defective train samples** | 17 | 35 | 53 |
| **precision** | 0.38926174496644295 | 0.5546218487394958 | 0.5777777777777777 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **recall** | 0.3625 | 0.4647887323943662 | 0.20967741935483872 |
| **pf** | 0.09109109109109109 | 0.059684684684684686 | 0.02445302445302445 |
| **F-measure** | 0.37540453074433655 | 0.5057471264367815 | 0.30769230769230765 |
| **accuracy** | 0.8334771354616048 | 0.874757281553398 | 0.8701442841287459 |
| **AUC** | 0.6357044544544544 | 0.7025520238548408 | 0.5926121974509072 |

## *2.5 GaussianProcessClassifier*

GaussianProcessClassifier (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5909090909090909 | 0.6461538461538462 | 0.6833333333333333 |
| **recall** | 0.3132530120481928 | 0.5675675675675675 | 0.6307692307692307 |
| **pf** | 0.07692307692307693 | 0.11057692307692307 | 0.1043956043956044 |
| **F-measure** | 0.40944881889763785 | 0.6043165467625901 | 0.6559999999999999 |
| **accuracy** | 0.7634069400630915 | 0.8049645390070922 | 0.8259109311740891 |
| **AUC** | 0.6181649675625579 | 0.7284953222453222 | 0.7631868131868133 |

GaussianProcessClassifier (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.5909090909090909 | 0.5142857142857142 | 0.5757575757575758 |
| **recall** | 0.38235294117647056 | 0.3 | 0.3584905660377358 |
| **pf** | 0.08653846153846154 | 0.0918918918918919 | 0.08641975308641975 |
| **F-measure** | 0.46428571428571425 | 0.3789473684210526 | 0.441860465116279 |
| **accuracy** | 0.782608695652174 | 0.7591836734693878 | 0.7767441860465116 |
| **AUC** | 0.6479072398190044 | 0.6040540540540541 | 0.6360354064756581 |

GaussianProcessClassifier (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.5277777777777778 | 0.5585585585585585 | 0.7068965517241379 |
| **recall** | 0.3114754098360656 | 0.3803680981595092 | 0.5734265734265734 |
| **pf** | 0.4112903225806452 | 0.44545454545454544 | 0.3541666666666667 |
| **F-measure** | 0.3917525773195876 | 0.45255474452554745 | 0.6332046332046333 |
| **accuracy** | 0.4234527687296417 | 0.45054945054945056 | 0.602510460251046 |
| **AUC** | 0.4500925436277102 | 0.4674567763524819 | 0.6096299533799533 |

GaussianProcessClassifier (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.4857142857142857 | 0.5245901639344263 | 0.6086956521739131 |
| **recall** | 0.4358974358974359 | 0.463768115942029 | 0.45901639344262296 |
| **pf** | 0.23529411764705882 | 0.21323529411764705 | 0.15126050420168066 |
| **F-measure** | 0.45945945945945943 | 0.49230769230769234 | 0.5233644859813085 |
| **accuracy** | 0.6536796536796536 | 0.6780487804878049 | 0.7166666666666667 |
| **AUC** | 0.6003016591251885 | 0.625266410912191 | 0.6538779446204711 |

GaussianProcessClassifier (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.5833333333333334 | 0.5376344086021505 | 0.5833333333333334 |
| **recall** | 0.12034383954154727 | 0.16129032258064516 | 0.5166051660516605 |
| **pf** | 0.08 | 0.12912912912912913 | 0.3424657534246575 |
| **F-measure** | 0.1995249406175772 | 0.24813895781637718 | 0.5479452054794521 |
| **accuracy** | 0.5345303867403315 | 0.5287713841368584 | 0.5896980461811723 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **AUC** | 0.5201719197707737 | 0.516080596725758 | 0.5870697063135015 |

## 2.6 KNeighborsClassifier

KNeighborsClassifier (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5263157894736842 | 0.6610169491525424 | 0.5769230769230769 |
| **recall** | 0.3614457831325301 | 0.527027027027027 | 0.46153846153846156 |
| **pf** | 0.11538461538461539 | 0.09615384615384616 | 0.12087912087912088 |
| **F-measure** | 0.42857142857142855 | 0.5864661654135338 | 0.5128205128205129 |
| **accuracy** | 0.7476340694006309 | 0.8049645390070922 | 0.7692307692307693 |
| **AUC** | 0.6230305838739574 | 0.7154365904365904 | 0.6703296703296703 |

KNeighborsClassifier (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.546875 | 0.4166666666666667 | 0.5757575757575758 |
| **recall** | 0.5147058823529411 | 0.3333333333333333 | 0.3584905660377358 |
| **pf** | 0.13942307692307693 | 0.15135135135135136 | 0.08641975308641975 |
| **F-measure** | 0.5303030303030303 | 0.3703703703703704 | 0.441860465116279 |
| **accuracy** | 0.7753623188405797 | 0.7224489795918367 | 0.7767441860465116 |
| **AUC** | 0.6876414027149321 | 0.590990990990991 | 0.6360354064756581 |

KNeighborsClassifier (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.6108108108108108 | 0.6613756613756614 | 0.6811594202898551 |
| **recall** | 0.6174863387978142 | 0.7668711656441718 | 0.6573426573426573 |
| **pf** | 0.5806451612903226 | 0.5818181818181818 | 0.4583333333333333 |
| **F-measure** | 0.6141304347826086 | 0.7102272727272727 | 0.6690391459074733 |
| **accuracy** | 0.5374592833876222 | 0.6263736263736264 | 0.6108786610878661 |
| **AUC** | 0.5184205887537459 | 0.592526491912995 | 0.599504662004662 |

KNeighborsClassifier (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.4626865671641791 | 0.5263157894736842 | 0.6166666666666667 |
| **recall** | 0.3974358974358974 | 0.5797101449275363 | 0.6065573770491803 |
| **pf** | 0.23529411764705882 | 0.2647058823529412 | 0.19327731092436976 |
| **F-measure** | 0.42758620689655175 | 0.5517241379310345 | 0.6115702479338844 |
| **accuracy** | 0.6406926406926406 | 0.6829268292682927 | 0.7388888888888889 |
| **AUC** | 0.5810708898944191 | 0.6575021312872975 | 0.7066400330624054 |

KNeighborsClassifier (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.6209150326797386 | 0.5955414012738853 | 0.59 |
| **recall** | 0.5444126074498568 | 0.603225806451613 | 0.6531365313653137 |
| **pf** | 0.30933333333333335 | 0.3813813813813814 | 0.4212328767123288 |
| **F-measure** | 0.5801526717557252 | 0.5993589743589743 | 0.6199649737302977 |
| **accuracy** | 0.6201657458563536 | 0.6111975116640747 | 0.6145648312611013 |
| **AUC** | 0.6175396370582618 | 0.6109222125351158 | 0.6159518273264925 |

KNeighborsClassifier (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.65 | 0.47058823529411764 | 0.6 |
| **recall** | 0.325 | 0.2222222222222222 | 0.3870967741935484 |
| **pf** | 0.0958904109589041 | 0.13846153846153847 | 0.14035087719298245 |
| **F-measure** | 0.43333333333333335 | 0.3018867924528302 | 0.47058823529411764 |
| **accuracy** | 0.6991150442477876 | 0.6336633663366337 | 0.6931818181818182 |
| **AUC** | 0.614554794520548 | 0.541880341880342 | 0.623372948500283 |

## 2.7 MLPClassifier

MLPClassifier (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5423728813559322 | 0.546875 | 0.6410256410256411 |
| **recall** | 0.3855421686746988 | 0.47297297297297297 | 0.38461538461538464 |
| **pf** | 0.11538461538461539 | 0.13942307692307693 | 0.07692307692307693 |
| **F-measure** | 0.4507042253521127 | 0.5072463768115941 | 0.4807692307692308 |
| **accuracy** | 0.7539432176656151 | 0.7588652482269503 | 0.7813765182186235 |
| **AUC** | 0.6350787766450416 | 0.6667749480249481 | 0.6538461538461539 |

MLPClassifier (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.30120481927710846 | 0.5161290322580645 | 0.48717948717948717 |
| **recall** | 0.36764705882352944 | 0.5333333333333333 | 0.3584905660377358 |
| **pf** | 0.27884615384615385 | 0.16216216216216217 | 0.12345679012345678 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **F-measure** | 0.3311258278145696 | 0.5245901639344263 | 0.41304347826086957 |
| **accuracy** | 0.6340579710144928 | 0.763265306122449 | 0.7488372093023256 |
| **AUC** | 0.5444004524886878 | 0.6855855855855856 | 0.6175168879571394 |

MLPClassifier (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.6048780487804878 | 0.6848484848484848 | 0.673469387755102 |
| **recall** | 0.6775956284153005 | 0.6932515337423313 | 0.6923076923076923 |
| **pf** | 0.6532258064516129 | 0.4727272727272727 | 0.5 |
| **F-measure** | 0.6391752577319587 | 0.6890243902439025 | 0.6827586206896552 |
| **accuracy** | 0.5439739413680782 | 0.6263736263736264 | 0.6150627615062761 |
| **AUC** | 0.5121849109818438 | 0.6102621305075293 | 0.5961538461538461 |

MLPClassifier (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.6530612244897959 | 0.5303030303030303 | 0.55 |
| **recall** | 0.41025641025641024 | 0.5072463768115942 | 0.5409836065573771 |
| **pf** | 0.1111111111111111 | 0.22794117647058823 | 0.226890756302521 |
| **F-measure** | 0.5039370078740157 | 0.5185185185185185 | 0.5454545454545455 |
| **accuracy** | 0.7272727272727273 | 0.6829268292682927 | 0.6944444444444444 |
| **AUC** | 0.6495726495726495 | 0.6396526001705031 | 0.657046425127428 |

MLPClassifier (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.5935828877005348 | 0.5975232198142415 | 0.6186046511627907 |
| **recall** | 0.6361031518624641 | 0.6225806451612903 | 0.4907749077490775 |
| **pf** | 0.4053333333333333 | 0.39039039039039036 | 0.2808219178082192 |
| **F-measure** | 0.6141078838174274 | 0.6097946287519748 | 0.5473251028806585 |
| **accuracy** | 0.6146408839779005 | 0.6158631415241057 | 0.6092362344582594 |
| **AUC** | 0.6153849092645655 | 0.6160951273854499 | 0.6049764949704292 |

MLPClassifier (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.35398230088495575 | 0.3564356435643564 | 0.3522727272727273 |
| **recall** | 1.0 | 1.0 | 1.0 |
| **pf** | 1.0 | 1.0 | 1.0 |
| **F-measure** | 0.522875816993464 | 0.5255474452554745 | 0.5210084033613446 |
| **accuracy** | 0.35398230088495575 | 0.3564356435643564 | 0.3522727272727273 |
| **AUC** | 0.5 | 0.5 | 0.5 |

MLPClassifier (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.14695945945945946 | 0.2788104089219331 | 0.28761061946902655 |
| **recall** | 0.20518867924528303 | 0.9946949602122016 | 0.9848484848484849 |
| **pf** | 0.4525089605734767 | 0.9778225806451613 | 0.9274193548387096 |
| **F-measure** | 0.17125984251968504 | 0.4355400696864112 | 0.4452054794520548 |
| **accuracy** | 0.45324675324675323 | 0.2899926953981008 | 0.32387312186978295 |
| **AUC** | 0.3763398593359032 | 0.5084361897835202 | 0.5287145650048877 |

## 2.8 QuadraticDiscriminantAnalysis

QuadraticDiscriminantAnalysis (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.5609756097560976 | 0.6698113207547169 | 0.6739130434782609 |
| **recall** | 0.12568306010928962 | 0.8711656441717791 | 0.6503496503496503 |
| **pf** | 0.14516129032258066 | 0.6363636363636364 | 0.46875 |
| **F-measure** | 0.20535714285714288 | 0.7573333333333332 | 0.6619217081850534 |
| **accuracy** | 0.4201954397394137 | 0.6666666666666666 | 0.602510460251046 |
| **AUC** | 0.49026088489335445 | 0.6174010039040714 | 0.5907998251748252 |

QuadraticDiscriminantAnalysis (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.56047197640118 | 0.601593625498008 | 0.5977653631284916 |
| **recall** | 0.5444126074498568 | 0.4870967741935484 | 0.3948339483394834 |
| **pf** | 0.3973333333333333 | 0.3003003003003003 | 0.2465753424657534 |
| **F-measure** | 0.5523255813953489 | 0.5383244206773619 | 0.47555555555555556 |
| **accuracy** | 0.574585635359116 | 0.5972006220839814 | 0.5808170515097691 |
| **AUC** | 0.5735396370582617 | 0.5933982369466241 | 0.5741293029368649 |

QuadraticDiscriminantAnalysis (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.3341584158415842 | 0.5095057034220533 | 0.6159420289855072 |
| **recall** | 0.6367924528301887 | 0.35543766578249336 | 0.25757575757575757 |
| **pf** | 0.482078853046595 | 0.13004032258064516 | 0.06105990783410138 |
| **F-measure** | 0.4383116883116883 | 0.41874999999999996 | 0.36324786324786323 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **accuracy** | 0.5506493506493506 | 0.7282688093498905 | 0.7512520868113522 |
| **AUC** | 0.5773567998917969 | 0.6126986716009241 | 0.5982579248708281 |

## *2.9 RandomForestClassifier*

RandomForestClassifier (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5510204081632653 | 0.6557377049180327 | 0.6862745098039216 |
| **recall** | 0.3253012048192771 | 0.5405405405405406 | 0.5384615384615384 |
| **pf** | 0.09401709401709402 | 0.10096153846153846 | 0.08791208791208792 |
| **F-measure** | 0.409090909090909 | 0.5925925925925926 | 0.6034482758620688 |
| **accuracy** | 0.7539432176656151 | 0.8049645390070922 | 0.8137651821862348 |
| **AUC** | 0.6156420554010915 | 0.7197895010395011 | 0.7252747252747253 |

RandomForestClassifier (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.5348837209302325 | 0.5873015873015873 | 0.6923076923076923 |
| **recall** | 0.6764705882352942 | 0.6166666666666667 | 0.5094339622641509 |
| **pf** | 0.19230769230769232 | 0.14054054054054055 | 0.07407407407407407 |
| **F-measure** | 0.5974025974025974 | 0.6016260162601625 | 0.5869565217391305 |
| **accuracy** | 0.7753623188405797 | 0.8 | 0.8232558139534883 |
| **AUC** | 0.7420814479638009 | 0.738063063063063 | 0.7176799440950384 |

RandomForestClassifier (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.6697674418604651 | 0.6813186813186813 | 0.7446808510638298 |
| **recall** | 0.7868852459016393 | 0.7607361963190185 | 0.7342657342657343 |
| **pf** | 0.5725806451612904 | 0.5272727272727272 | 0.375 |
| **F-measure** | 0.7236180904522613 | 0.7188405797101449 | 0.7394366197183099 |
| **accuracy** | 0.6416938110749185 | 0.6446886446886447 | 0.6903765690376569 |
| **AUC** | 0.6071523003701744 | 0.6167317345231456 | 0.6796328671328671 |

RandomForestClassifier (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.5818181818181818 | 0.6567164179104478 | 0.6086956521739131 |
| **recall** | 0.41025641025641024 | 0.6376811594202898 | 0.6885245901639344 |
| **pf** | 0.1503267973856209 | 0.16911764705882354 | 0.226890756302521 |
| **F-measure** | 0.48120300751879697 | 0.6470588235294118 | 0.6461538461538463 |
| **accuracy** | 0.7012987012987013 | 0.7658536585365854 | 0.7444444444444445 |
| **AUC** | 0.6299648064353947 | 0.7342817561807331 | 0.7308169169307067 |

RandomForestClassifier (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.5931758530183727 | 0.654275092936803 | 0.6486486486486487 |
| **recall** | 0.6475644699140402 | 0.567741935483871 | 0.7084870848708487 |
| **pf** | 0.41333333333333333 | 0.27927927927927926 | 0.3561643835616438 |
| **F-measure** | 0.6191780821917807 | 0.6079447322970639 | 0.6772486772486772 |
| **accuracy** | 0.6160220994475138 | 0.6469673405909798 | 0.6749555950266429 |
| **AUC** | 0.6171155682903534 | 0.6442313281022958 | 0.6761613506546024 |

RandomForestClassifier (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.6190476190476191 | 0.375 | 0.5555555555555556 |
| **recall** | 0.325 | 0.25 | 0.3225806451612903 |
| **pf** | 0.1095890410958904 | 0.23076923076923078 | 0.14035087719298245 |
| **F-measure** | 0.42622950819672134 | 0.3 | 0.40816326530612246 |
| **accuracy** | 0.6902654867256637 | 0.5841584158415841 | 0.6704545454545454 |
| **AUC** | 0.6077054794520548 | 0.5096153846153846 | 0.5911148839841539 |

RandomForestClassifier (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.4611872146118721 | 0.5955555555555555 | 0.5977011494252874 |
| **recall** | 0.23820754716981132 | 0.35543766578249336 | 0.3151515151515151 |
| **pf** | 0.1057347670250896 | 0.09173387096774194 | 0.08064516129032258 |
| **F-measure** | 0.31415241057542764 | 0.44518272425249167 | 0.41269841269841273 |
| **accuracy** | 0.7136363636363636 | 0.7560262965668371 | 0.7529215358931552 |
| **AUC** | 0.5662363900723608 | 0.6318518974073757 | 0.6172531769305962 |

## *2.10 SVC*

SVC (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.6046511627906976 | 0.6530612244897959 | 0.6724137931034483 |
| **recall** | 0.3132530120481928 | 0.43243243243243246 | 0.6 |
| **pf** | 0.07264957264957266 | 0.08173076923076923 | 0.1043956043956044 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **F-measure** | 0.41269841269841273 | 0.5203252032520326 | 0.6341463414634146 |
| **accuracy** | 0.7665615141955836 | 0.7907801418439716 | 0.8178137651821862 |
| **AUC** | 0.62030171969931 | 0.6753508316008315 | 0.7478021978021979 |

SVC (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.574468085106383 | 0.6037735849056604 | 0.6341463414634146 |
| **recall** | 0.34615384615384615 | 0.463768115942029 | 0.4262295081967213 |
| **pf** | 0.13071895424836602 | 0.15441176470588236 | 0.12605042016806722 |
| **F-measure** | 0.43200000000000005 | 0.5245901639344263 | 0.5098039215686274 |
| **accuracy** | 0.6926406926406926 | 0.7170731707317073 | 0.7222222222222222 |
| **AUC** | 0.6077174459527401 | 0.6546781756180733 | 0.6500895440143271 |

SVC (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.6703910614525139 | 0.6282722513089005 | 0.7121212121212122 |
| **recall** | 0.3438395415472779 | 0.3870967741935484 | 0.17343173431734318 |
| **pf** | 0.15733333333333333 | 0.2132132132132132 | 0.06506849315068493 |
| **F-measure** | 0.4545454545454545 | 0.4790419161676647 | 0.2789317507418398 |
| **accuracy** | 0.6022099447513812 | 0.5940902021772939 | 0.5683836589698046 |
| **AUC** | 0.5932531041069723 | 0.5869417804901677 | 0.5541816205833292 |

SVC (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.8571428571428571 | 1.0 | 0.7333333333333333 |
| **recall** | 0.15 | 0.027777777777777776 | 0.3548387096774194 |
| **pf** | 0.0136986301369863 | 0.0 | 0.07017543859649122 |
| **F-measure** | 0.2553191489361702 | 0.05405405405405406 | 0.47826086956521735 |
| **accuracy** | 0.6902654867256637 | 0.6534653465346535 | 0.7272727272727273 |
| **AUC** | 0.5681506849315068 | 0.5138888888888888 | 0.6423316355404641 |

## *2.11 XGBOD*

XGBOD (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.547945205479452 | 0.5686274509803921 | 0.5555555555555556 |
| **recall** | 0.4819277108433735 | 0.3918918918918919 | 0.5384615384615384 |
| **pf** | 0.14102564102564102 | 0.10576923076923077 | 0.15384615384615385 |
| **F-measure** | 0.5128205128205129 | 0.464 | 0.5468749999999999 |
| **accuracy** | 0.7602523659305994 | 0.7624113475177305 | 0.7651821862348178 |
| **AUC** | 0.6704510349088663 | 0.6430613305613305 | 0.6923076923076922 |

XGBOD (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.37037037037037035 | 0.44285714285714284 | 0.6341463414634146 |
| **recall** | 0.14705882352941177 | 0.5166666666666667 | 0.49056603773584906 |
| **pf** | 0.08173076923076923 | 0.21081081081081082 | 0.09259259259259259 |
| **F-measure** | 0.21052631578947367 | 0.47692307692307695 | 0.5531914893617021 |
| **accuracy** | 0.7282608695652174 | 0.7224489795918367 | 0.8046511627906977 |
| **AUC** | 0.5326640271493213 | 0.6529279279279279 | 0.6989867225716283 |

XGBOD (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.6363636363636364 | 0.7094972067039106 | 0.695364238410596 |
| **recall** | 0.6502732240437158 | 0.7791411042944786 | 0.7342657342657343 |
| **pf** | 0.5483870967741935 | 0.4727272727272727 | 0.4791666666666667 |
| **F-measure** | 0.6432432432432432 | 0.7426900584795323 | 0.7142857142857142 |
| **accuracy** | 0.5700325732899023 | 0.6776556776556777 | 0.6485355648535565 |
| **AUC** | 0.5509430636347612 | 0.653206915783603 | 0.6275495337995337 |

XGBOD (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.4766355140186916 | 0.55 | 0.5757575757575758 |
| **recall** | 0.6538461538461539 | 0.4782608695652174 | 0.6229508196721312 |
| **pf** | 0.3660130718954248 | 0.19852941176470587 | 0.23529411764705882 |
| **F-measure** | 0.5513513513513513 | 0.5116279069767442 | 0.5984251968503937 |
| **accuracy** | 0.6406926406926406 | 0.6926829268292682 | 0.7166666666666667 |
| **AUC** | 0.6439165409753644 | 0.6398657289002557 | 0.693828351012536 |

XGBOD (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.6184615384615385 | 0.597972972972973 | 0.6085626911314985 |
| **recall** | 0.5759312320916905 | 0.5709677419354838 | 0.7343173431734318 |
| **pf** | 0.33066666666666666 | 0.35735735735735735 | 0.4383561643835616 |
| **F-measure** | 0.5964391691394659 | 0.5841584158415841 | 0.6655518394648829 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **accuracy** | 0.6243093922651933 | 0.6080870917573873 | 0.6447602131438721 |
| **AUC** | 0.6226322827125119 | 0.6068051922890632 | 0.6479805893949351 |

XGBOD (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.4166666666666667 | 0.5789473684210527 | 0.4666666666666667 |
| **recall** | 0.25 | 0.3055555555555556 | 0.6774193548387096 |
| **pf** | 0.1917808219178082 | 0.12307692307692308 | 0.42105263157894735 |
| **F-measure** | 0.3125 | 0.4000000000000001 | 0.5526315789473684 |
| **accuracy** | 0.6106194690265486 | 0.6732673267326733 | 0.6136363636363636 |
| **AUC** | 0.5291095890410958 | 0.5912393162393162 | 0.6281833616298811 |

XGBOD (NASA/pc4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 128 | 257 | 386 |
| **defective train samples** | 17 | 35 | 53 |
| **precision** | 0.5740740740740741 | 0.44285714285714284 | 0.6753246753246753 |
| **recall** | 0.3875 | 0.21830985915492956 | 0.41935483870967744 |
| **pf** | 0.04604604604604605 | 0.04391891891891892 | 0.032175032175032175 |
| **F-measure** | 0.4626865671641791 | 0.29245283018867924 | 0.5174129353233831 |
| **accuracy** | 0.8757549611734253 | 0.8543689320388349 | 0.8923418423973363 |
| **AUC** | 0.6707269769769769 | 0.5871954701180052 | 0.6935899032673227 |

XGBOD (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.4878048780487805 | 0.5741444866920152 | 0.59 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **recall** | 0.2830188679245283 | 0.4005305039787798 | 0.3575757575757576 |
| **pf** | 0.11290322580645161 | 0.11290322580645161 | 0.0944700460829493 |
| **F-measure** | 0.3582089552238806 | 0.47187500000000004 | 0.44528301886792454 |
| **accuracy** | 0.7207792207792207 | 0.7531044558071585 | 0.7545909849749582 |
| **AUC** | 0.5850578210590383 | 0.6438136390861641 | 0.6315528557464042 |

# 3 论文算法复现

## *3.1 ISDA*

一种改进的子类判别分析算法（Improved Subclass Discriminant Analysis），主要用于处理类不平衡问题。同时，通过 SSTCA 进行特征迁移，可实现跨项目缺陷预测。 [1]

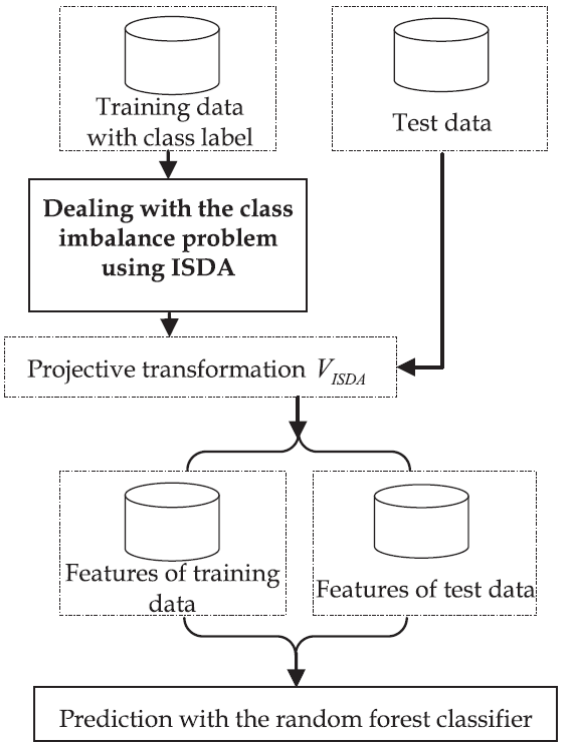


TABLE 3
ISDA-Based Within-Project Prediction

| | |
|---|---|
| **Input:** | $X = [X_1, X_2]$ and $y$. |
| **Output:** | Class label of $y$. |
| **Step 1.** | Determine the optimal number of subclass $H_{1opt}$ for the defective class and the optimal number $H_{2opt}$ for the defect-free class by using the improved LOOT criterion in Formula (4). |
| **Step 2.** | Separately divide $X_1$ and $X_2$ into $H_{1opt}$ and $H_{2opt}$ subclasses by using the NNC algorithm [42]. |
| **Step 3.** | For the obtained $H_{opt} = H_{1opt} + H_{2opt}$ subclasses, calculate $\Sigma_B$ and $\Sigma_X$ by using Formulae (2) and (3), respectively. |
| **Step 4.** | Obtain the projective transformation $V$ by using Formula (1), which consists of eigen-vectors corresponding to the nonzero eigen-values of $\Sigma_X^{-1}\Sigma_B$. |
| **Step 5.** | Obtain the projected features of the training data and target instance by using $X^f = V^T X$ and $y^f = V^T y$. |
| **Step 6.** | Use the random forest classifier to classify $y^f$. |

TABLE 4
SSTCA+ISDA for Cross-Project Prediction

| | |
|---|---|
| **Input:** | $X_S$ and $X_T$. |
| **Output:** | Class labels of instances in $X_T$. |
| **Step 1.** | Input $X_S$ and $X_T$ into the SSTCA method and achieve the transferred source and target project data $X'_S$ and $X'_T$. |
| **Step 2.** | Regard $X'_S$ as the training data and learn ISDA projective transformation $V$. |
| **Step 3.** | Obtain the projected features of $X'_S$ and $X'_T$ by using $X_S^f = V^T X'_S$ and $X_T^f = V^T X'_T$. |
| **Step 4.** | Use the random forest classifier to classify each instance in $X_T^f$. |

ISDA (CK/ant1)

| | **10%** | **20%** | **30%** |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.4666666666666667 | 0.47368421052631576 | 0.543859649122807 |
| **recall** | 0.42168674698795183 | 0.4864864864864865 | 0.47692307692307695 |
| **pf** | 0.17094017094017094 | 0.19230769230769232 | 0.14285714285714285 |
| **F-measure** | 0.4430379746835443 | 0.4799999999999999 | 0.5081967213114754 |
| **accuracy** | 0.722397476340694 | 0.723404255319149 | 0.757085020242915 |
| **AUC** | 0.6253732880238904 | 0.6470893970893971 | 0.6670329670329671 |

ISDA (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 33 | 67 | 101 |
| **defective train samples** | 20 | 40 | 60 |
| **precision** | 0.56 | 0.6162162162162163 | 0.6506849315068494 |
| **recall** | 0.5355191256830601 | 0.6993865030674846 | 0.6643356643356644 |
| **pf** | 0.6209677419354839 | 0.6454545454545455 | 0.53125 |
| **F-measure** | 0.547486033519553 | 0.6551724137931035 | 0.6574394463667821 |
| **accuracy** | 0.4723127035830619 | 0.5604395604395604 | 0.5857740585774058 |
| **AUC** | 0.4572756918737882 | 0.5269659788064696 | 0.5665428321678322 |

ISDA (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.5164835164835165 | 0.46153846153846156 | 0.5 |
| **recall** | 0.6025641025641025 | 0.5217391304347826 | 0.5901639344262295 |
| **pf** | 0.2875816993464052 | 0.3088235294117647 | 0.3025210084033613 |
| **F-measure** | 0.5562130177514794 | 0.4897959183673469 | 0.5413533834586466 |
| **accuracy** | 0.6753246753246753 | 0.6341463414634146 | 0.6611111111111111 |
| **AUC** | 0.6574912016088487 | 0.606457800511509 | 0.6438214630114341 |

ISDA (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.5866666666666667 | 0.5539568345323741 | 0.5475285171102662 |
| **recall** | 0.6303724928366762 | 0.4967741935483871 | 0.5313653136531366 |
| **pf** | 0.41333333333333333 | 0.37237237237237236 | 0.4075342465753425 |
| **F-measure** | 0.6077348066298343 | 0.5238095238095238 | 0.5393258426966292 |
| **accuracy** | 0.6077348066298343 | 0.5645412130637636 | 0.5630550621669627 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **AUC** | 0.6085195797516715 | 0.5622009105880074 | 0.561915533538897 |

ISDA (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.5909090909090909 | 0.5333333333333333 | 0.4827586206896552 |
| **recall** | 0.325 | 0.4444444444444444 | 0.45161290322580644 |
| **pf** | 0.1232876712328767 | 0.2153846153846154 | 0.2631578947368421 |
| **F-measure** | 0.41935483870967744 | 0.4848484848484848 | 0.4666666666666667 |
| **accuracy** | 0.6814159292035398 | 0.6633663366336634 | 0.6363636363636364 |
| **AUC** | 0.6008561643835616 | 0.6145299145299146 | 0.5942275042444822 |

ISDA (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.33729216152019004 | 0.4022346368715084 | 0.32558139534883723 |
| **recall** | 0.33490566037735847 | 0.3819628647214854 | 0.296969696969697 |
| **pf** | 0.25 | 0.2157258064516129 | 0.23387096774193547 |
| **F-measure** | 0.336094674556213 | 0.39183673469387753 | 0.31061806656101426 |
| **accuracy** | 0.6357142857142857 | 0.6734842951059167 | 0.6368948247078464 |
| **AUC** | 0.5424528301886792 | 0.5831185291349363 | 0.5315493646138807 |

## *3.2 BaggingClassifierPU*

一种半监督分类器，利用正样本和无标签样本。 [2]

BaggingClassifierPU (CK/ant1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 34 | 69 | 104 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **defective train samples** | 9 | 18 | 27 |
| **precision** | 0.5333333333333333 | 0.4915254237288136 | 0.4576271186440678 |
| **recall** | 0.5783132530120482 | 0.7837837837837838 | 0.8307692307692308 |
| **pf** | 0.1794871794871795 | 0.28846153846153844 | 0.3516483516483517 |
| **F-measure** | 0.5549132947976878 | 0.6041666666666666 | 0.5901639344262295 |
| **accuracy** | 0.7570977917981072 | 0.7304964539007093 | 0.6963562753036437 |
| **AUC** | 0.6994130367624344 | 0.7476611226611226 | 0.7395604395604396 |

BaggingClassifierPU (CK/ivy2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 35 | 70 | 105 |
| **defective train samples** | 4 | 8 | 12 |
| **precision** | 0.2753623188405797 | 0.24210526315789474 | 0.30158730158730157 |
| **recall** | 0.5277777777777778 | 0.71875 | 0.6785714285714286 |
| **pf** | 0.17793594306049823 | 0.288 | 0.2009132420091324 |
| **F-measure** | 0.3619047619047619 | 0.36220472440944884 | 0.41758241758241754 |
| **accuracy** | 0.7886435331230284 | 0.7127659574468085 | 0.7854251012145749 |
| **AUC** | 0.6749209173586397 | 0.715375 | 0.7388290932811481 |

BaggingClassifierPU (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 30 | 61 | 91 |
| **defective train samples** | 7 | 15 | 22 |
| **precision** | 0.3240223463687151 | 0.36363636363636365 | 0.4074074074074074 |
| **recall** | 0.8529411764705882 | 0.8 | 0.6226415094339622 |
| **pf** | 0.5817307692307693 | 0.4540540540540541 | 0.2962962962962963 |
| **F-measure** | 0.46963562753036436 | 0.5000000000000001 | 0.49253731343283585 |
| **accuracy** | 0.5253623188405797 | 0.6081632653061224 | 0.6837209302325581 |
| **AUC** | 0.6356052036199095 | 0.672972972972973 | 0.6631726065688329 |

BaggingClassifierPU (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 25 | 51 | 76 |
| **defective train samples** | 8 | 17 | 25 |
| **precision** | 0.48863636363636365 | 0.4948453608247423 | 0.52 |
| **recall** | 0.5512820512820513 | 0.6956521739130435 | 0.8524590163934426 |
| **pf** | 0.29411764705882354 | 0.3602941176470588 | 0.40336134453781514 |
| **F-measure** | 0.5180722891566266 | 0.5783132530120482 | 0.6459627329192545 |
| **accuracy** | 0.6536796536796536 | 0.6585365853658537 | 0.6833333333333333 |
| **AUC** | 0.6285822021116139 | 0.6676790281329923 | 0.7245488359278137 |

BaggingClassifierPU (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 79 | 160 | 240 |
| **defective train samples** | 38 | 77 | 116 |
| **precision** | 0.5528455284552846 | 0.5956873315363881 | 0.5988857938718662 |
| **recall** | 0.7793696275071633 | 0.7129032258064516 | 0.7933579335793358 |
| **pf** | 0.5866666666666667 | 0.45045045045045046 | 0.4931506849315068 |
| **F-measure** | 0.6468489892984542 | 0.6490455212922174 | 0.6825396825396826 |
| **accuracy** | 0.5897790055248618 | 0.6283048211508554 | 0.6447602131438721 |
| **AUC** | 0.5963514804202483 | 0.6312263876780005 | 0.6501036243239146 |

BaggingClassifierPU (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 12 | 24 | 37 |
| **defective train samples** | 4 | 8 | 13 |
| **precision** | 0.4528301886792453 | 0.410958904109589 | 0.5454545454545454 |
| **recall** | 0.6 | 0.8333333333333334 | 0.7741935483870968 |
| **pf** | 0.3972602739726027 | 0.6615384615384615 | 0.3508771929824561 |
| **F-measure** | 0.5161290322580645 | 0.5504587155963302 | 0.64 |
| **accuracy** | 0.6017699115044248 | 0.5148514851485149 | 0.6931818181818182 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **AUC** | 0.6013698630136987 | 0.585897435897436 | 0.7116581777023203 |

BaggingClassifierPU (NASA/pc3)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 107 | 214 | 322 |
| **defective train samples** | 13 | 26 | 40 |
| **precision** | 0.2837370242214533 | 0.24456521739130435 | 0.25075528700906347 |
| **recall** | 0.6776859504132231 | 0.8333333333333334 | 0.8829787234042553 |
| **pf** | 0.24381625441696114 | 0.36821192052980134 | 0.3751891074130106 |
| **F-measure** | 0.4 | 0.3781512605042017 | 0.39058823529411774 |
| **accuracy** | 0.7463917525773196 | 0.657010428736964 | 0.6569536423841059 |
| **AUC** | 0.716934847998131 | 0.7325607064017661 | 0.7538948079956224 |

BaggingClassifierPU (NASA/pc4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 128 | 257 | 386 |
| **defective train samples** | 17 | 35 | 53 |
| **precision** | 0.3347547974413646 | 0.35543766578249336 | 0.4166666666666667 |
| **recall** | 0.98125 | 0.9436619718309859 | 0.9274193548387096 |
| **pf** | 0.3123123123123123 | 0.27364864864864863 | 0.2072072072072072 |
| **F-measure** | 0.4992050874403816 | 0.5163776493256261 | 0.5750000000000001 |
| **accuracy** | 0.728213977566868 | 0.7563106796116504 | 0.8113207547169812 |
| **AUC** | 0.8344688438438438 | 0.8350066615911685 | 0.8601060738157512 |

BaggingClassifierPU (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **train samples** | 171 | 342 | 513 |
| **defective train samples** | 47 | 94 | 141 |
| **precision** | 0.4244604316546763 | 0.42199108469539376 | 0.4066115702479339 |
| **recall** | 0.6957547169811321 | 0.753315649867374 | 0.7454545454545455 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **pf** | 0.35842293906810035 | 0.39213709677419356 | 0.41359447004608296 |
| **F-measure** | 0.5272564789991063 | 0.540952380952381 | 0.5262032085561498 |
| **accuracy** | 0.6564935064935065 | 0.647918188458729 | 0.6302170283806344 |
| **AUC** | 0.6686658889565159 | 0.6805892765465902 | 0.6659300377042313 |

## *3.3 JSFS*

一种联合贝叶斯半监督特征选择和分类算法（JSFS），该算法采用贝叶斯方法自动选择相关特征并同时学习分类器。 [3]

数据预处理：为解决数据量小，数据分布不均衡的问题, 使用SMOTE算法生成新的样本.

SMOTE算法流程：

1、采样KNN算法，计算出每个少数类样本的K个近邻;

2、从K个近邻中随机挑选N个样本进行随机线性插值;

3、构造新的少数类样本;

4、将新样本与原数据合成，产生新的训练集;

扩充后的数据集结果：

| 类别 | 比例 | 训练数据 | | | 测试数据 | | |
|---|---|---|---|---|---|---|---|
| | | 总数 | 正例 | 负例 | 总数 | 正例 | 负例 |
| ant1 | 10% | 50 | 25 | 25 | 317 | 83 | 234 |
| | 20% | 102 | 51 | 51 | 282 | 74 | 208 |
| | 30% | 154 | 77 | 77 | 247 | 65 | 182 |
| ivy2 | 10% | 62 | 31 | 31 | 317 | 36 | 281 |
| | 20% | 124 | 62 | 62 | 282 | 32 | 250 |
| | 30% | 186 | 93 | 93 | 247 | 28 | 219 |
| jedit4 | 10% | 46 | 23 | 23 | 276 | 68 | 208 |
| | 20% | 92 | 46 | 46 | 245 | 60 | 185 |
| | 30% | 138 | 69 | 69 | 215 | 53 | 162 |
| lucene2 | 10% | 40 | 20 | 20 | 307 | 183 | 124 |
| | 20% | 80 | 40 | 40 | 273 | 163 | 110 |
| | 30% | 120 | 60 | 60 | 239 | 143 | 96 |
| synapse1 | 10% | 34 | 17 | 17 | 231 | 78 | 153 |
| | 20% | 68 | 34 | 34 | 205 | 69 | 136 |
| | 30% | 102 | 51 | 51 | 180 | 61 | 119 |
| velocity1 | 10% | 10 | 5 | 5 | 93 | 60 | 33 |
| | 20% | 30 | 15 | 15 | 83 | 50 | 33 |
| | 30% | 38 | 19 | 19 | 73 | 46 | 27 |
| xalan2 | 10% | 82 | 41 | 41 | 724 | 349 | 375 |
| | 20% | 166 | 83 | 83 | 643 | 310 | 333 |
| | 30% | 248 | 124 | 124 | 563 | 271 | 292 |

| 类别 | 比例 | 训练数据 | | | 测试数据 | | |
|---|---|---|---|---|---|---|---|
| | | 总数 | 正例 | 负例 | 总数 | 正例 | 负例 |
| cm1 | 10% | 56 | 28 | 28 | 295 | 38 | 257 |
| | 20% | 114 | 57 | 57 | 262 | 34 | 228 |
| | 30% | 170 | 85 | 85 | 230 | 30 | 200 |
| kc3 | 10% | 30 | 15 | 15 | 176 | 33 | 143 |
| | 20% | 62 | 31 | 31 | 156 | 29 | 127 |
| | 30% | 94 | 47 | 47 | 137 | 26 | 111 |
| mc2 | 10% | 16 | 8 | 8 | 113 | 40 | 73 |
| | 20% | 32 | 16 | 16 | 101 | 36 | 65 |
| | 30% | 48 | 24 | 24 | 88 | 31 | 57 |
| mw1 | 10% | 44 | 22 | 22 | 229 | 25 | 204 |
| | 20% | 90 | 45 | 45 | 203 | 22 | 181 |
| | 30% | 134 | 67 | 67 | 178 | 19 | 159 |
| pc1 | 10% | 128 | 64 | 64 | 635 | 55 | 580 |
| | 20% | 256 | 128 | 128 | 565 | 49 | 516 |
| | 30% | 386 | 193 | 193 | 494 | 43 | 451 |
| pc3 | 10% | 188 | 94 | 94 | 970 | 121 | 849 |
| | 20% | 376 | 188 | 188 | 863 | 108 | 755 |
| | 30% | 564 | 282 | 282 | 755 | 94 | 661 |
| pc4 | 10% | 222 | 111 | 111 | 1159 | 160 | 999 |
| | 20% | 444 | 222 | 222 | 1030 | 142 | 888 |
| | 30% | 666 | 333 | 333 | 901 | 124 | 777 |
| pc5 | 10% | 248 | 124 | 124 | 1540 | 424 | 1116 |
| | 20% | 496 | 248 | 248 | 1369 | 377 | 992 |
| | 30% | 744 | 372 | 372 | 1198 | 330 | 868 |

JSFS算法流程：

**Algorithm 1** The proposed JSFS algorithm

**Input:** Training data $\boldsymbol{X} \in \mathbb{R}^{n \times d}$, parameters $\gamma$ and $\mu$.
**Output:** The selected feature indexes and their corresponding weight vector $\boldsymbol{w}$ for the linear classifier.
Initialize $w_i$, $\lambda_j$, $\alpha_i$, and $c_j$ for $i = 1, \ldots, d$ and $j = l+1, \ldots, n$.
Construct the affinity matrix $\boldsymbol{S}$ and graph Laplacian $\boldsymbol{L}$.
Obtain the pseudo label vector $\widetilde{\boldsymbol{y}}_u$ via label propagation.
**While** $\max_i |w_i^{\text{new}} - w_i^{\text{old}}| > 10^{-3}$ **do**
  **If** $\|\boldsymbol{g}_w\|/d < 10^{-3}$ **then**
    Fix $\boldsymbol{\lambda}$, compute $\boldsymbol{g}_w$ and $\boldsymbol{H}_w$ by Eqs . (10) and (11), and update $\boldsymbol{w} \leftarrow \boldsymbol{w} - \boldsymbol{H}_w^{-1}\boldsymbol{g}_w$;
  **end if**
  Remove the $i$-th feature if $|w_i| < 10^{-3}$;
  **If** $\|\boldsymbol{g}_\lambda\|/u < 10^{-3}$ **then**
    Fix $\boldsymbol{w}$, compute $\boldsymbol{g}_\lambda$ and $\boldsymbol{H}_\lambda$ by Eqs . (13) and (14), and update $\boldsymbol{\lambda} \leftarrow \boldsymbol{\lambda} - \boldsymbol{H}_\lambda^{-1}\boldsymbol{g}_\lambda$;
  **end if**
  Remove the $j$-th unlabeled sample if $|\lambda_j| < 10^{-3}$;
  Update $\boldsymbol{\alpha}$ and $\boldsymbol{c}$ using Eqs. (18) and (20);
**end while**

JSFS与每个数据集的超参等配置见文件config.json

由于JSFS本身是半监督的，为了更好的效果，基本上保留了所有CK或NASA的数据标签

JSFS的情况与问题：

1、论文实验中部分超参缺少说明；

2、算法收敛条件固定，使得需要将x的特征值归一化到0-0.001等很小的值才能达到收敛条件；

3、算法要么不收敛，要么在前五次迭代即收敛，与数据集相关；

4、求出的y的值往往值域、量级或精确度差别较大，缺少二分类的可解释性说明，效果很受对y值二分类阈值划分的影响，而论文未说明；

5、算法过程中包含其他模型的使用，这些模型相关的选取与参数配置未说明，且没做消融实验等；

JSFS实验结果：

JSFS (CK/ant1)

| | **10%** | **20%** | **30%** |
|---|---|---|---|
| **precision** | 0.5625 | 0.5434782608695652 | 0.4956521739130435 |
| **recall** | 0.43373493975903615 | 0.33783783783783783 | 0.8769230769230769 |
| **pf** | 0.11965811965811966 | 0.10096153846153846 | 0.31868131868131866 |
| **F-measure** | 0.4897959183673469 | 0.41666666666666663 | 0.6333333333333333 |
| **accuracy** | 0.7634069400630915 | 0.75177304964539 | 0.7327935222672065 |
| **AUC** | 0.6570384100504583 | 0.6184381496881496 | 0.7791208791208791 |

JSFS (CK/ivy2)

| | **10%** | **20%** | **30%** |
|---|---|---|---|
| **precision** | 0.6666666666666666 | 0.25 | 0.21686746987951808 |
| **recall** | 0.1111111111111111 | 0.5625 | 0.6428571428571429 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **pf** | 0.0071174377224199285 | 0.216 | 0.2968036529680365 |
| **F-measure** | 0.1904761904761905 | 0.34615384615384615 | 0.32432432432432434 |
| **accuracy** | 0.8927444794952681 | 0.7588652482269503 | 0.6963562753036437 |
| **AUC** | 0.5519968366943456 | 0.67325 | 0.6730267449445533 |

JSFS (CK/jedit4)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.717948717948718 | 0.373015873015873 | 0.37815126050420167 |
| **recall** | 0.4117647058823529 | 0.7833333333333333 | 0.8490566037735849 |
| **pf** | 0.052884615384615384 | 0.42702702702702705 | 0.4567901234567901 |
| **F-measure** | 0.5233644859813085 | 0.5053763440860215 | 0.5232558139534883 |
| **accuracy** | 0.8152173913043478 | 0.6244897959183674 | 0.6186046511627907 |
| **AUC** | 0.6794400452488687 | 0.678153153153153 | 0.6961332401583974 |

JSFS (CK/lucene2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.7687074829931972 | 0.7019867549668874 | 0.7007874015748031 |
| **recall** | 0.6174863387978142 | 0.6503067484662577 | 0.6223776223776224 |
| **pf** | 0.27419354838709675 | 0.4090909090909091 | 0.3958333333333333 |
| **F-measure** | 0.6848484848484848 | 0.6751592356687899 | 0.6592592592592593 |
| **accuracy** | 0.6612377850162866 | 0.6263736263736264 | 0.6150627615062761 |
| **AUC** | 0.6716463952053587 | 0.6206079196876743 | 0.6132721445221446 |

JSFS (CK/synapse1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.4632352941176471 | 0.43283582089552236 | 0.4330708661417323 |
| **recall** | 0.8076923076923077 | 0.8405797101449275 | 0.9016393442622951 |
| **pf** | 0.477124183006536 | 0.5588235294117647 | 0.6050420168067226 |
| **F-measure** | 0.588785046728972 | 0.5714285714285715 | 0.5851063829787234 |
| **accuracy** | 0.6190476190476191 | 0.5756097560975609 | 0.5666666666666667 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **AUC** | 0.6652840623428858 | 0.6408780903665814 | 0.6482986637277862 |

JSFS (CK/velocity1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.7627118644067796 | 0.85 | 0.7058823529411765 |
| **recall** | 0.75 | 0.34 | 0.782608695652174 |
| **pf** | 0.42424242424242425 | 0.09090909090909091 | 0.5555555555555556 |
| **F-measure** | 0.7563025210084034 | 0.4857142857142858 | 0.7422680412371134 |
| **accuracy** | 0.6881720430107527 | 0.5662650602409639 | 0.6575342465753424 |
| **AUC** | 0.6628787878787877 | 0.6245454545454546 | 0.6135265700483092 |

JSFS (CK/xalan2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.5585585585585585 | 0.515625 | 0.48491879350348027 |
| **recall** | 0.3553008595988539 | 0.6387096774193548 | 0.7712177121771218 |
| **pf** | 0.2613333333333333 | 0.5585585585585585 | 0.7602739726027398 |
| **F-measure** | 0.4343257443082311 | 0.5706051873198847 | 0.5954415954415955 |
| **accuracy** | 0.5538674033149171 | 0.536547433903577 | 0.4955595026642984 |
| **AUC** | 0.5469837631327603 | 0.5400755594303982 | 0.5054718697871909 |

JSFS (NASA/cm1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.39361702127659576 | 0.6829268292682927 | 0.4520547945205479 |
| **recall** | 1.0 | 0.875 | 0.9705882352941176 |
| **pf** | 0.22093023255813954 | 0.05652173913043478 | 0.20408163265306123 |
| **F-measure** | 0.5648854961832062 | 0.767123287671233 | 0.616822429906542 |
| **accuracy** | 0.8067796610169492 | 0.9351145038167938 | 0.8217391304347826 |
| **AUC** | 0.8895348837209303 | 0.9092391304347827 | 0.8832533013205283 |

JSFS (NASA/kc3)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 1.0 | 0.4146341463414634 | 0.5217391304347826 |
| **recall** | 0.29411764705882354 | 0.9444444444444444 | 1.0 |
| **pf** | 0.0 | 0.17391304347826086 | 0.088 |
| **F-measure** | 0.45454545454545453 | 0.576271186440678 | 0.6857142857142856 |
| **accuracy** | 0.9318181818181818 | 0.8397435897435898 | 0.9197080291970803 |
| **AUC** | 0.6470588235294118 | 0.8852657004830918 | 0.9560000000000001 |

JSFS (NASA/mc2)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.6666666666666666 | 0.3783783783783784 | 0.3611111111111111 |
| **recall** | 0.4 | 0.7368421052631579 | 0.9285714285714286 |
| **pf** | 0.043010752688172046 | 0.2804878048780488 | 0.3108108108108108 |
| **F-measure** | 0.5 | 0.5 | 0.52 |
| **accuracy** | 0.8584070796460177 | 0.7227722772277227 | 0.7272727272727273 |
| **AUC** | 0.678494623655914 | 0.7281771501925546 | 0.8088803088803089 |

JSFS (NASA/mw1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.45121951219512196 | 0.49295774647887325 | 0.4262295081967213 |
| **recall** | 1.0 | 1.0 | 1.0 |
| **pf** | 0.234375 | 0.21428571428571427 | 0.23026315789473684 |
| **F-measure** | 0.6218487394957983 | 0.660377358490566 | 0.5977011494252873 |
| **accuracy** | 0.8034934497816594 | 0.8226600985221675 | 0.8033707865168539 |
| **AUC** | 0.8828125 | 0.8928571428571428 | 0.8848684210526316 |

JSFS (NASA/pc1)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.2018348623853211 | 0.3978494623655914 | 0.7666666666666667 |
| **recall** | 1.0 | 1.0 | 0.7931034482758621 |
| **pf** | 0.29441624365482233 | 0.10606060606060606 | 0.015053763440860216 |

| | 10% | 20% | 30% |
|---|---|---|---|
| **F-measure** | 0.33587786259541985 | 0.5692307692307692 | 0.7796610169491527 |
| **accuracy** | 0.7259842519685039 | 0.9008849557522124 | 0.9736842105263158 |
| **AUC** | 0.8527918781725888 | 0.9469696969696969 | 0.889024842417501 |

JSFS (NASA/pc3)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.6619718309859155 | 0.352112676056338 | 0.8222222222222222 |
| **recall** | 0.8703703703703703 | 0.9615384615384616 | 0.7872340425531915 |
| **pf** | 0.026200873362445413 | 0.11344019728729964 | 0.011299435028248588 |
| **F-measure** | 0.752 | 0.5154639175257731 | 0.8043478260869565 |
| **accuracy** | 0.9680412371134021 | 0.8910776361529548 | 0.976158940397351 |
| **AUC** | 0.9220847485039624 | 0.924049132125581 | 0.8879673037624715 |

JSFS (NASA/pc4)

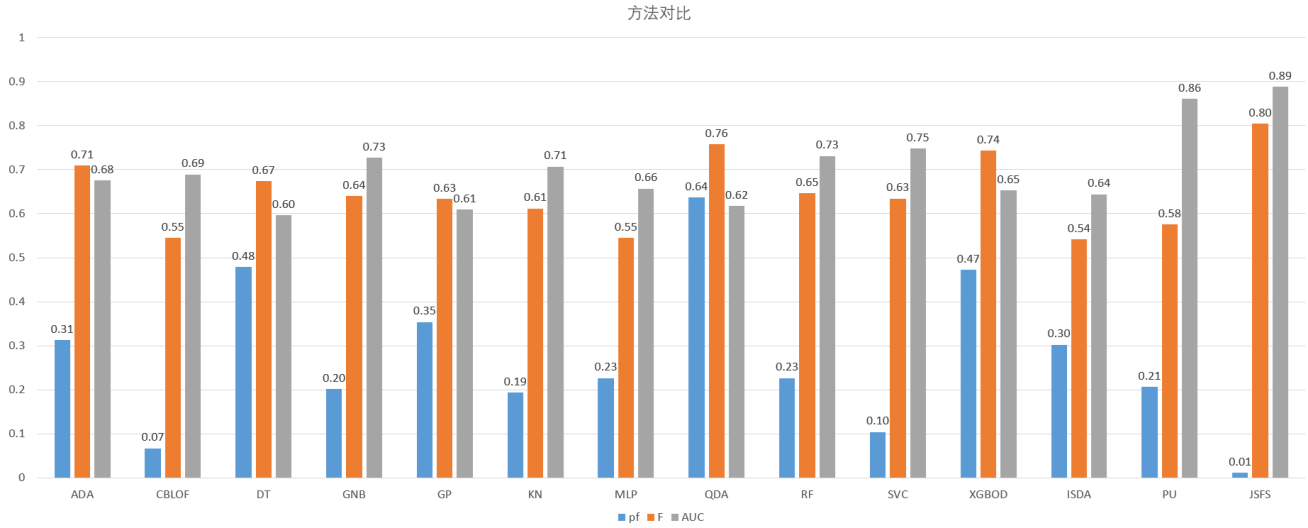
| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 0.5925925925925926 | 0.25806451612903225 | 0.3142857142857143 |
| **recall** | 0.6956521739130435 | 0.8421052631578947 | 0.7333333333333333 |
| **pf** | 0.009683098591549295 | 0.04549950544015826 | 0.02708803611738149 |
| **F-measure** | 0.6399999999999999 | 0.3950617283950617 | 0.44 |
| **accuracy** | 0.9844693701466781 | 0.9524271844660194 | 0.9689234184239733 |
| **AUC** | 0.8429845376607471 | 0.8983028788588683 | 0.8531226486079759 |

JSFS (NASA/pc5)

| | 10% | 20% | 30% |
|---|---|---|---|
| **precision** | 1.0 | 0.996742671009772 | 1.0 |
| **recall** | 0.6516257465162575 | 0.6866118175018698 | 0.5501285347043702 |
| **pf** | 0.0 | 0.09375 | 0.0 |
| **F-measure** | 0.7890719164323022 | 0.8131089459698848 | 0.7097844112769487 |
| **accuracy** | 0.6590909090909091 | 0.6917457998539079 | 0.5617696160267112 |
| **AUC** | 0.8258128732581287 | 0.7964309087509349 | 0.775064267352185 |

# 总结分析

对于现有分类器的评估，还是随机森林大法好，F值最高能达到0.7以上。其它方法各有优缺点，但统一的情况都会出现部分测试数据集的结果很不理想。对于论文算法的复现，ISDA 算法主要处理类不平衡问题，可能由于本次测试数据集规模较小，表现并不佳。BaggingClassifierPU 和 JSFS 在 CK 和 NASA 上的表现都不错，JSFS 甚至能达到 0.8 以上的F值。

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