Experiment Results

Experiment1

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 100000
Causal relations: **Totally linear**, except for L2, L5, L5 = abs(L2)**2 + logistic(0,.1)

Result

getData: 100000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 0.0
dependence ('L1', 'L2', ['A']) = 0.0006412786449668806
dependence ('L1', 'L2', ['A', 'B']) = 0.0005214736183126734
dependence ('L2', 'L3') = 0.0
dependence ('L1', 'L3') = 1.1248514344419647e-06
dependence ('E1', 'E2') = 0.0
dependence ('N1', 'N2') = 1.0037415343333578e-11
dependence ('L4', 'L5') = 3.043565399707404e-12
dependence ('L5', 'L6') = 0.0
dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 0.0
dependence ('L6', 'L7', ['L3']) = 0.11731401732126201
dependence ('L4', 'L6', ['L3']) = 0.45588685718345834
dependence ('L8', 'L9', ['L1']) = 0.004811470193597178
dependence ('B', 'D', ['A']) = 0.6934239226097391
dependence ('A', 'C', ['B', 'D']) = 0.00032709597532165624
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 0.9999999999999847
dependence ('L5', 'L2') = 0.999999999999954
dependence ('L6', 'L3') = 0.9999999999999387

dependence ('L6', 'L7') = 1.0000000000000306
dependence ('L7', 'L4') = 0.9999999999999694
dependence ('E3', 'E1') = 0.999999999999977
dependence ('E3', 'E2') = 1.0000000000000153
dependence ('M1', 'N2') = 1.0000000000000153
dependence ('B', 'D') = 1.000000000000046
dependence ('B', 'D', 'C') = 1.000000000000003
dependence ('B', 'D', ['A', 'C']) = 1.0
dependence ('B', 'A', 'C') = 1.0
dependence ('B', 'A', ['C', 'D']) = 1.0
dependence ('B', 'C', 'A') = 1.000000000000003
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 0.9999999999999387
dependence ('N1', 'N2', ['N3']) = 1.000000000000009
dependence ('N3', 'E1', ['M1']) = 1.000000000000006
dependence ('M1', 'E2', ['E3']) = 0.9999999999999835

Maximum dependence for expected independents = 0.6934239226097391
Minimum dependence for expected dependents = 0.9999999999999387
Margin = 0.30657607739019965 . Positive margin is good.
Maximum dependence = 1.000000000000046
best Low threshold is: 0.8467119613048388
best High threshold is: 1.100000000000046

Test Time = 209

Setting2

Method: RCoT
Seed: 1
Fourier features: 100 5
Sample size: 100000
Causal relations: Totally linear, except for L2, L5, L5 = abs(L2)**2 + logistic(0,.1)

Result2

getData: 100000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 4.596323321948148e-14
dependence ('L1', 'L2', ['A']) = 0.003041478222725935
dependence ('L1', 'L2', ['A', 'B']) = 0.002963619324721889
dependence ('L2', 'L3') = 0.0
dependence ('L1', 'L3') = 0.0

dependence ('E1', 'E2') = 0.0
dependence ('N1', 'N2') = 0.02750097601202528
dependence ('L4', 'L5') = 1.8444135108097726e-12
dependence ('L5', 'L6') = 0.0
dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 5.793165247514054e-08
dependence ('L6', 'L7', ['L3']) = 0.0023921381797908925
dependence ('L4', 'L6', ['L3']) = 0.2523155152378631
dependence ('L8', 'L9', ['L1']) = 0.0
dependence ('B', 'D', ['A']) = 0.38137340951451915
dependence ('A', 'C', ['B', 'D']) = 1.182798436971666e-07
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 0.9999999999999617
dependence ('L5', 'L2') = 1.0000000000000306
dependence ('L6', 'L3') = 0.9999999999999617
dependence ('L6', 'L7') = 0.9999999999999923
dependence ('L7', 'L4') = 0.9999999999999923
dependence ('E3', 'E1') = 0.9999999999999694
dependence ('E3', 'E2') = 0.9999999999999464
dependence ('M1', 'N2') = 1.0000000000000613
dependence ('B', 'D') = 1.0000000000000153
dependence ('B', 'D', 'C') = 1.0
dependence ('B', 'D', ['A', 'C']) = 1.0
dependence ('B', 'A', 'C') = 1.0
dependence ('B', 'A', ['C', 'D']) = 1.0
dependence ('B', 'C', 'A') = 1.0
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 0.9999999999999694
dependence ('N1', 'N2', ['N3']) = 1.0
dependence ('N3', 'E1', ['M1']) = 1.000000000000009
dependence ('M1', 'E2', ['E3']) = 1.000000000000003

Maximum dependence for expected independents = 0.38137340951451915
Minimum dependence for expected dependents = 0.9999999999999464
Margin = 0.6186265904854272 . Positive margin is good.
Maximum dependence = 1.0000000000000613
best Low threshold is: 0.6906867047572327
best High threshold is: 1.1000000000000614

Test Time = 208

Experiment2

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 10000
Causal relations: Totally linear, except for L2, L5, L5 = abs(L2)**2 + logistic(0,.1)

Result

getData: 10000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 0.0
dependence ('L1', 'L2', ['A']) = 1.7763568394002505e-15
dependence ('L1', 'L2', ['A', 'B']) = 6.661338147750939e-16
dependence ('L2', 'L3') = 0.0
dependence ('L1', 'L3') = 8.038014698286133e-13
dependence ('E1', 'E2') = 1.598620458231892e-09
dependence ('N1', 'N2') = 0.0
dependence ('L4', 'L5') = 3.976082796341984e-10
dependence ('L5', 'L6') = 0.0
dependence ('L4', 'N3') = 0.00016083072688144462
dependence ('C', 'E2') = 0.0
dependence ('L6', 'L7', ['L3']) = 2.666548467666896e-05
dependence ('L4', 'L6', ['L3']) = 1.5634250264184857e-05
dependence ('L8', 'L9', ['L1']) = 2.3155699580001965e-11
dependence ('B', 'D', ['A']) = 3.300835547392911e-05
dependence ('A', 'C', ['B', 'D']) = 0.023937834303212835
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 0.9999999999999617
dependence ('L5', 'L2') = 1.0
dependence ('L6', 'L3') = 1.0000000000001072
dependence ('L6', 'L7') = 0.9999999999999617
dependence ('L7', 'L4') = 1.0
dependence ('E3', 'E1') = 1.0000000000000613
dependence ('E3', 'E2') = 1.000000000000092

dependence ('M1', 'N2') = 0.999999999999931
dependence ('B', 'D') = 0.9999999999999694
dependence ('B', 'D', 'C') = 1.0
dependence ('B', 'D', ['A', 'C']) = 1.0
dependence ('B', 'A', 'C') = 1.0
dependence ('B', 'A', ['C', 'D']) = 1.0
dependence ('B', 'C', 'A') = 1.0
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 1.0000000000000153
dependence ('N1', 'N2', ['N3']) = 0.999999999999994
dependence ('N3', 'E1', ['M1']) = 0.9999999999999925
dependence ('M1', 'E2', ['E3']) = 0.9999999999999895

Maximum dependence for expected independents = 0.023937834303212835
Minimum dependence for expected dependents = 0.999999999999931
Margin = 0.9760621656967182 . Positive margin is good.
Maximum dependence = 1.0000000000001072
best Low threshold is: 0.511968917151572
best High threshold is: 1.1000000000001073

Test Time = 196

Experiment3

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 1000
Causal relations: Totally linear, except for L2, L5, L5 = abs(L2)**2 + logistic(0,.1)

Result

getData: 1000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 3.238863621746191e-10
dependence ('L1', 'L2', ['A']) = 0.0025441310504631387
dependence ('L1', 'L2', ['A', 'B']) = 0.007158872533656213
dependence ('L2', 'L3') = 0.04172578351350842
dependence ('L1', 'L3') = 0.0
dependence ('E1', 'E2') = 0.0

dependence ('N1', 'N2') = 0.0
dependence ('L4', 'L5') = 0.11131127326263912
dependence ('L5', 'L6') = 1.1011173851604994e-06
dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 0.0
dependence ('L6', 'L7', ['L3']) = 7.66053886991358e-14
dependence ('L4', 'L6', ['L3']) = 0.04011968682761069
dependence ('L8', 'L9', ['L1']) = 1.1290968160437842e-12
dependence ('B', 'D', ['A']) = 3.444244889294623e-12
dependence ('A', 'C', ['B', 'D']) = 4.440892098500626e-16
dependence ('M1', 'E2') = 5.513878242879855e-11
dependence ('M1', 'E2') = 5.513878242879855e-11

Testing expected dependents:

dependence ('L3', 'L4') = 0.9999999999999694
dependence ('L5', 'L2') = 0.999999999999977
dependence ('L6', 'L3') = 0.9999999999999923
dependence ('L6', 'L7') = 1.0000000000000153
dependence ('L7', 'L4') = 1.0
dependence ('E3', 'E1') = 1.0
dependence ('E3', 'E2') = 0.9999999999999923
dependence ('M1', 'N2') = 1.0000000000000613
dependence ('B', 'D') = 1.0000000000000153
dependence ('B', 'D', 'C') = 0.9999999999977226
dependence ('B', 'D', ['A', 'C']) = 0.9998159772056895
dependence ('B', 'A', 'C') = 1.0
dependence ('B', 'A', ['C', 'D']) = 1.000000000000003
dependence ('B', 'C', 'A') = 1.0
dependence ('A', 'C', 'B') = 0.9999999999999984
dependence ('L8', 'L9') = 1.000000000000046
dependence ('N1', 'N2', ['N3']) = 0.999999998645423
dependence ('N3', 'E1', ['M1']) = 0.999999999999994
dependence ('M1', 'E2', ['E3']) = 0.9823061906380568

Maximum dependence for expected independents = 0.11131127326263912
Minimum dependence for expected dependents = 0.9823061906380568
Margin = 0.8709949173754177 . Positive margin is good.
Maximum dependence = 1.0000000000000613
best Low threshold is: 0.546808731950348
best High threshold is: 1.1000000000000614

Test Time = 190

Experiment4

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 100000
Causal relations: Using non-linear relations for A, B, C, D

Result

getData: 100000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 4.2968240077101427e-10
dependence ('L1', 'L2', ['A']) = 0.015836863175451854
dependence ('L1', 'L2', ['A', 'B']) = 0.015981199865108597
dependence ('L2', 'L3') = 0.0
dependence ('L1', 'L3') = 0.0
dependence ('E1', 'E2') = 3.8568348403877906e-08
dependence ('N1', 'N2') = 0.0
dependence ('L4', 'L5') = 0.0
dependence ('L5', 'L6') = 8.745943969046266e-10
dependence ('L4', 'N3') = 6.451984508881736e-07
dependence ('C', 'E2') = 0.0
dependence ('L6', 'L7', ['L3']) = 4.531447028277569e-06
dependence ('L4', 'L6', ['L3']) = 0.0008156743357976559
dependence ('L8', 'L9', ['L1']) = 0.0
dependence ('B', 'D', ['A']) = 0.0017189253861034093
dependence ('A', 'C', ['B', 'D']) = 1.000000000000003
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 1.0000000000000153
dependence ('L5', 'L2') = 0.999999999999977
dependence ('L6', 'L3') = 0.999999999999977
dependence ('L6', 'L7') = 1.0000000000000766
dependence ('L7', 'L4') = 0.9999999999999387
dependence ('E3', 'E1') = 0.999999999999954
dependence ('E3', 'E2') = 0.999999999999931

dependence ('M1', 'N2') = 1.0
dependence ('B', 'D') = 1.0000000000000153
dependence ('B', 'D', 'C') = 1.000000000000009
dependence ('B', 'D', ['A', 'C']) = 0.9999655025545914
dependence ('B', 'A', 'C') = 1.000000000000006
dependence ('B', 'A', ['C', 'D']) = 1.0
dependence ('B', 'C', 'A') = 0.9999999999999984
dependence ('A', 'C', 'B') = 1.000000000000033
dependence ('L8', 'L9') = 0.999999999999954
dependence ('N1', 'N2', ['N3']) = 0.999999999999985
dependence ('N3', 'E1', ['M1']) = 0.999999999999991
dependence ('M1', 'E2', ['E3']) = 0.9999999999999835

Maximum dependence for expected independents = 1.000000000000003
Minimum dependence for expected dependents = 0.9999655025545914
Margin = -3.449744541172972e-05 . Positive margin is good.
Maximum dependence = 1.0000000000000766
best Low threshold is: 1.001000000000003
best High threshold is: 1.1000000000000767

Test Time = 202

Experiment5

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 10000
Causal relations: Using non-linear relationS for A, B, C, D

Result

getData: 10000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 0.0
dependence ('L1', 'L2', ['A']) = 0.0001413093574741397 5
dependence ('L1', 'L2', ['A', 'B']) = 0.00031321490403479757
dependence ('L2', 'L3') = 0.0
dependence ('L1', 'L3') = 0.17309703997681858
dependence ('E1', 'E2') = 1.546540673302843e-13

dependence ('N1', 'N2') = 0.0
dependence ('L4', 'L5') = 0.0
dependence ('L5', 'L6') = 0.7347294932947959
dependence ('L4', 'N3') = 0.408869597932498
dependence ('C', 'E2') = 1.099120794378905e-14
dependence ('L6', 'L7', ['L3']) = 1.290093004646664e-07
dependence ('L4', 'L6', ['L3']) = 0.007154277613731219
dependence ('L8', 'L9', ['L1']) = 0.00040053105936432853
dependence ('B', 'D', ['A']) = 0.05346477823958995
dependence ('A', 'C', ['B', 'D']) = 0.9040328787035714
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 1.000000000000046
dependence ('L5', 'L2') = 1.000000000000046
dependence ('L6', 'L3') = 1.000000000000092
dependence ('L6', 'L7') = 1.0000000000000306
dependence ('L7', 'L4') = 0.9999999999999617
dependence ('E3', 'E1') = 1.0000000000000306
dependence ('E3', 'E2') = 0.999999999999977
dependence ('M1', 'N2') = 0.9999999999999234
dependence ('B', 'D') = 1.0000000000000153
dependence ('B', 'D', 'C') = 0.9999999999999925
dependence ('B', 'D', ['A', 'C']) = 0.4418022492245881
dependence ('B', 'A', 'C') = 0.9999999999999984
dependence ('B', 'A', ['C', 'D']) = 1.0
dependence ('B', 'C', 'A') = 0.9506994360568294
dependence ('A', 'C', 'B') = 1.000000000000006
dependence ('L8', 'L9') = 0.9999999999999694
dependence ('N1', 'N2', ['N3']) = 1.000000000000006
dependence ('N3', 'E1', ['M1']) = 0.999999999999994
dependence ('M1', 'E2', ['E3']) = 1.000000000000003

Maximum dependence for expected independents = 0.9040328787035714
Minimum dependence for expected dependents = 0.4418022492245881
Margin = -0.4622306294789833 . Positive margin is good.
Maximum dependence = 1.000000000000092
best Low threshold is: 0.9050328787035714
best High threshold is: 1.100000000000092

Test Time = 192

Experiment6

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 10000
Causal relations: Using **very strong non-linear relations** for all variables

```
varEquations = [
            #'B = choice(range(-bRange, bRange+1))',
            # A bunch of independent variables with different distributions
            'L1= logistic(0, 1)',
            'L2 = logistic(0, 1)',
            'L3 = logistic(100, .5)',
            'E1 = exponential()',
            'E2 = exponential()',
            'N1 = normal(0,1)',
            'N2 = normal(-10, 2)',
            # Some dependent variables on above distributions
            'L4 = L3 + logistic(0,.5)',
            'L5 = abs(L2)**2 + logistic(0,.1)',
            'L6 = .5 * L3 + logistic(0,.1) if choice([0,1]) else abs(L3)**3 + logistic(0, .1)',
            'L7 = 1 * L3 + logistic(0, .1) if choice([0,1]) else math.tanh(L3)**3 + logistic(0, .1)',
            'L8 = 1 * L1 + logistic(0, 1) if choice([0,1]) else abs(L1)**3 + logistic(0, 1)',
            'L9 = 1 * L1 + logistic(0, 1) if choice([0,1]) else math.tanh(L1)**3 + logistic(0, 1)',
            'E3 = E1 + .5 / E2 + logistic(0,.1)',
            'N3 = N1 * math.sin(N2) + exponential()',
            'N4 = N1 + normal(0, .1)',
            'N5 = N1 + normal(0, .1)',
            'M1 = N3 / (math.cos(E1) + 1) + normal(0,.1)',

            # Model M3 with subtle conditional independencies
            'B = logistic(0,1)',
          'A = abs(B)**1.2 + logistic(0,.1)',
            'D = 1 * math.sin(A) + logistic(0,.1)',
          'C = .5 * abs(B)**.5 + .5 * math.cos(D) + logistic(0,.1)',
            't = t + 1'
           ]
```

Result

getData: 10000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 0.0
dependence ('L1', 'L2', ['A']) = 6.552889342259505e-10
dependence ('L1', 'L2', ['A', 'B']) = 3.943911863757421e-11
dependence ('L2', 'L3') = 1.1102230246251565e-15
dependence ('L1', 'L3') = 0.0
dependence ('E1', 'E2') = 0.0
dependence ('N1', 'N2') = 0.0
dependence ('L4', 'L5') = 0.0
dependence ('L5', 'L6') = 0.0
dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 2.7230890738194624e-05
dependence ('L6', 'L7', ['L3']) = 4.1115710835981645e-10
dependence ('L4', 'L6', ['L3']) = 0.24476614664367824
dependence ('L8', 'L9', ['L1']) = 0.999886599555841
dependence ('B', 'D', ['A']) = 0.6284885150316963
dependence ('A', 'C', ['B', 'D']) = 0.999999999999976
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 1.0000000000000306
dependence ('L5', 'L2') = 1.000000000000046
dependence ('L6', 'L3') = 0.999987121204543
dependence ('L6', 'L7') = 0.0
dependence ('L7', 'L4') = 0.001805205119736697
dependence ('E3', 'E1') = 1.0000000000000306
dependence ('E3', 'E2') = 0.9999999999999694
dependence ('M1', 'N2') = 0.0
dependence ('B', 'D') = 0.9999999999999923
dependence ('B', 'D', 'C') = 1.000000000000003
dependence ('B', 'D', ['A', 'C']) = 0.8713621206811955
dependence ('B', 'A', 'C') = 1.000000000000006
dependence ('B', 'A', ['C', 'D']) = 0.999999999999997
dependence ('B', 'C', 'A') = 0.8599505143845623
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 0.999999999999977
dependence ('N1', 'N2', ['N3']) = 5.10702591327572e-15
dependence ('N3', 'E1', ['M1']) = 0.999999999999997

dependence ('M1', 'E2', ['E3']) = 0.9999999999999984

Maximum dependence for expected independents = 0.999999999999976
Minimum dependence for expected dependents = 0.0
Margin = -0.999999999999976 . Positive margin is good.
Maximum dependence = 1.000000000000046
best Low threshold is: 1.000999999999976
best High threshold is: 1.100000000000046

Test Time = 195

Result2

getData: 10000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 0.0
dependence ('L1', 'L2', ['A']) = 1.3088027096541666e-06
dependence ('L1', 'L2', ['A', 'B']) = 1.8869318607617203e-07
dependence ('L2', 'L3') = 2.883489698124464e-07
dependence ('L1', 'L3') = 0.0
dependence ('E1', 'E2') = 0.0
dependence ('N1', 'N2') = 1.1102230246251565e-16
dependence ('L4', 'L5') = 0.0
dependence ('L5', 'L6') = 0.0
dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 1.6517599510379455e-09
dependence ('L6', 'L7', ['L3']) = 3.964126582545191e-09
dependence ('L4', 'L6', ['L3']) = 0.008863438282806002
dependence ('L8', 'L9', ['L1']) = 0.9999825385566766
dependence ('B', 'D', ['A']) = 0.8833604874653249
dependence ('A', 'C', ['B', 'D']) = 0.9999999961704448
dependence ('M1', 'E2') = 1.139780714254357e-09
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 1.0000000000001072
dependence ('L5', 'L2') = 1.0
dependence ('L6', 'L3') = 0.9719515284202045
dependence ('L6', 'L7') = 0.0
dependence ('L7', 'L4') = 9.026057790073594e-09
dependence ('E3', 'E1') = 0.9999999999999387
dependence ('E3', 'E2') = 1.000000000000046

dependence ('M1', 'N2') = 4.758082816636033e-12
dependence ('B', 'D') = 1.0000000000000153
dependence ('B', 'D', 'C') = 0.9999999998320741
dependence ('B', 'D', ['A', 'C']) = 0.9114632983765636
dependence ('B', 'A', 'C') = 0.9999999999999925
dependence ('B', 'A', ['C', 'D']) = 0.999999999999994
dependence ('B', 'C', 'A') = 0.05812028653508727
dependence ('A', 'C', 'B') = 0.9999266816023422
dependence ('L8', 'L9') = 1.0000000000000153
dependence ('N1', 'N2', ['N3']) = 1.4215467802891624e-08
dependence ('N3', 'E1', ['M1']) = 0.9999999999999895
dependence ('M1', 'E2', ['E3']) = 1.000000000000003

Maximum dependence for expected independents = 0.9999999961704448
Minimum dependence for expected dependents = 0.0
Margin = -0.9999999961704448 . Positive margin is good.
Maximum dependence = 1.0000000000001072
best Low threshold is: 1.0009999961704448
best High threshold is: 1.1000000000001073

Test Time = 201

Experiment7

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 100000
Causal relations: Using **very strong non-linear relations** for all variables

```
varEquations = [
        #'B = choice(range(-bRange, bRange+1))',
        # A bunch of independent variables with different distributions
        'L1= logistic(0, 1)',
        'L2 = logistic(0, 1)',
        'L3 = logistic(100, .5)',
        'E1 = exponential()',
        'E2 = exponential()',
        'N1 = normal(0,1)',
        'N2 = normal(-10, 2)',
        # Some dependent variables on above distributions
```

```
    'L4 = L3 + logistic(0,.5)',
    'L5 = abs(L2)**2 + logistic(0,.1)',
    'L6 = .5 * L3 + logistic(0,.1) if choice([0,1]) else abs(L3)**3 + logistic(0, .1)',
    'L7 = 1 * L3 + logistic(0, .1) if choice([0,1]) else math.tanh(L3)**3 + logistic(0, .1)',
    'L8 = 1 * L1 + logistic(0, 1) if choice([0,1]) else abs(L1)**3 + logistic(0, 1)',
    'L9 = 1 * L1 + logistic(0, 1) if choice([0,1]) else math.tan(L1)**3 + logistic(0, 1)',
    'E3 = E1 + .5 / E2 + logistic(0,.1)',
    'N3 = N1 * math.sin(N2) + exponential()',
    'N4 = N1 + normal(0, .1)',
    'N5 = N1 + normal(0, .1)',
    'M1 = N3 / (math.cos(E1) + 1) + normal(0,.1)',

    # Model M3 with subtle conditional independencies
    'B = logistic(0,1)',
  'A = abs(B)**1.2 + logistic(0,.1)',
    'D = 1 * math.sin(A) + logistic(0,.1)',
  'C = .5 * abs(B)**.5 + .5 * math.cos(D) + logistic(0,.1)',
    't = t + 1'
  ]
```

Result

```
getData:  100000 records read.

Testing expected independents:
dependence ('L1', 'L2') =  0.0
dependence ('L1', 'L2', ['A']) =  0.0
dependence ('L1', 'L2', ['A', 'B']) =  8.84980266846469e-09
dependence ('L2', 'L3') =  0.0
dependence ('L1', 'L3') =  6.666146048495136e-07
dependence ('E1', 'E2') =  4.4297898682543746e-14
dependence ('N1', 'N2') =  0.0
dependence ('L4', 'L5') =  0.0
dependence ('L5', 'L6') =  5.10702591327572e-13
dependence ('L4', 'N3') =  0.0
dependence ('C', 'E2') =  6.8194339064575615e-12
dependence ('L6', 'L7', ['L3']) =  0.011751570015421153
dependence ('L4', 'L6', ['L3']) =  0.0011425108647493687
dependence ('L8', 'L9', ['L1']) =  0.9999999999997404
dependence ('B', 'D', ['A']) =  0.0
dependence ('A', 'C', ['B', 'D']) =  1.0
dependence ('M1', 'E2') =  0.0011374263842651722
dependence ('M1', 'E2') =  8.612019585074737e-05
```

Testing expected dependents:

dependence ('L3', 'L4') = 0.9999999999999617
dependence ('L5', 'L2') = 0.9999999999999923
dependence ('L6', 'L3') = 0.9999999999996784
dependence ('L6', 'L7') = 4.396556452235245e-10
dependence ('L7', 'L4') = 8.309697374642155e-11
dependence ('E3', 'E1') = 1.0
dependence ('E3', 'E2') = 1.0000000000000153
dependence ('M1', 'N2') = 1.1819454507455696e-05
dependence ('B', 'D') = 0.999999999999977
dependence ('B', 'D', 'C') = 1.000000000000024
dependence ('B', 'D', ['A', 'C']) = 0.0038295182069070233
dependence ('B', 'A', 'C') = 0.9999999999999925
dependence ('B', 'A', ['C', 'D']) = 0.9999999999999805
dependence ('B', 'C', 'A') = 0.41375040621363435
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 1.0
dependence ('N1', 'N2', ['N3']) = 0.586812019131959
dependence ('N3', 'E1', ['M1']) = 1.000000000000015
dependence ('M1', 'E2', ['E3']) = 0.999999999999997

Maximum dependence for expected independents = 1.0
Minimum dependence for expected dependents = 8.309697374642155e-11
Margin = -0.999999999916903 . Positive margin is good.
Maximum dependence = 1.000000000000024
best Low threshold is: 1.001
best High threshold is: 1.100000000000024

Test Time = 226

Experiment8

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 10000
Causal relations: Using **mild non-linear relations** for all variables

varEquations = [

```
    #'B = choice(range(-bRange, bRange+1))',
    # A bunch of independent variables with different distributions
    'L1= logistic(0, 1)',
    'L2 = logistic(0, 1)',
    'L3 = logistic(100, .5)',
    'E1 = exponential()',
    'E2 = exponential()',
    'N1 = normal(0,1)',
    'N2 = normal(-10, 2)',
    # Some dependent variables on above distributions
    'L4 = L3 + logistic(0,.5)',
    'L5 = abs(L2)**2 + logistic(0,.1)',
    'L6 = .5 * L3**2 + logistic(0,.1)',
    'L7 = 1 * L3**2 + logistic(0, .1)',
    'L8 = 1 * L1**2 + logistic(0, 1)',
    'L9 = 1 * L1**2 + logistic(0, 1)',
    'E3 = E1 + E2 + logistic(0,.1)',
    'N3 = N1 * N2 + exponential()',
    'N4 = N1 + normal(0, .1)',
    'N5 = N1 + normal(0, .1)',
    'M1 = N3 / (E1 + 1) + normal(0,.1)',

    # Model M3 with subtle conditional independencies
    'B = logistic(0,1)',
  'A = abs(B)**1.1 + logistic(0,.1)',
    'D = 1 * A + logistic(0,.1)',
  'C = .5 * abs(B) + .5 * D + logistic(0,.1)',
    't = t + 1'
   ]
```

Result

```
getData:  10000 records read.

Testing expected independents:
dependence ('L1', 'L2') =  5.047040563255223e-11
dependence ('L1', 'L2', ['A']) =  3.7070028013896916e-07
dependence ('L1', 'L2', ['A', 'B']) =  0.0043885930715682475
dependence ('L2', 'L3') =  1.1102230246251565e-16
dependence ('L1', 'L3') =  0.0
dependence ('E1', 'E2') =  0.0
dependence ('N1', 'N2') =  0.0
dependence ('L4', 'L5') =  2.8668178941870792e-12
dependence ('L5', 'L6') =  2.4424906541753444e-15
```

dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 3.8673062209060305e-05
dependence ('L6', 'L7', ['L3']) = 0.9940450941714262
dependence ('L4', 'L6', ['L3']) = 1.4443897718985355e-06
dependence ('L8', 'L9', ['L1']) = 1.0
dependence ('B', 'D', ['A']) = 2.7099322785772983e-11
dependence ('A', 'C', ['B', 'D']) = 0.733213137431639
dependence ('M1', 'E2') = 1.971400820366398e-11
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 1.0000000000000613
dependence ('L5', 'L2') = 0.9999999999999694
dependence ('L6', 'L3') = 0.999999999999931
dependence ('L6', 'L7') = 1.0000000000000153
dependence ('L7', 'L4') = 1.0000000000000153
dependence ('E3', 'E1') = 0.9999999999999617
dependence ('E3', 'E2') = 0.9999999999999694
dependence ('M1', 'N2') = 0.9999999618357862
dependence ('B', 'D') = 0.999999999999954
dependence ('B', 'D', 'C') = 0.9561091101362892
dependence ('B', 'D', ['A', 'C']) = 2.119703163439013e-06
dependence ('B', 'A', 'C') = 0.998320829354834
dependence ('B', 'A', ['C', 'D']) = 1.0
dependence ('B', 'C', 'A') = 0.9716279483024771
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 1.0000000000000153
dependence ('N1', 'N2', ['N3']) = 0.9999999999999925
dependence ('N3', 'E1', ['M1']) = 0.9999999999999984
dependence ('M1', 'E2', ['E3']) = 1.0

Maximum dependence for expected independents = 1.0
Minimum dependence for expected dependents = 2.119703163439013e-06
Margin = -0.9999978802968366 . Positive margin is good.
Maximum dependence = 1.0000000000000613
best Low threshold is: 1.001
best High threshold is: 1.1000000000000614

Test Time = 197

Experiment9

Setting

Method: RCoT
Seed: 0
Fourier features: 100 5
Sample size: 10000
Causal relations: Using **mild non-linear relations** for all variables

```
varEquations = [
            #'B = choice(range(-bRange, bRange+1))',
            # A bunch of independent variables with different distributions
            'L1= logistic(0, 1)',
            'L2 = logistic(0, 1)',
            'L3 = logistic(100, .5)',
            'E1 = exponential()',
            'E2 = exponential()',
            'N1 = normal(0,1)',
            'N2 = normal(-10, 2)',
            # Some dependent variables on above distributions
            'L4 = L3 + logistic(0,.5)',
            'L5 = abs(L2)**1.5 + logistic(0,.1)',
            'L6 = .5 * abs(L3)**1.5 + logistic(0,.1)',
            'L7 = 1 * abs(L3)**1.5 + logistic(0, .1)',
            'L8 = 1 * abs(L1)**1.5 + logistic(0, 1)',
            'L9 = 1 * abs(L1)**1.5 + logistic(0, 1)',
            'E3 = E1 + E2 + logistic(0,.1)',
            'N3 = N1 * N2 + exponential()',
            'N4 = N1 + normal(0, .1)',
            'N5 = N1 + normal(0, .1)',
            'M1 = N3 / (E1 + 1) + normal(0,.1)',

            # Model M3 with subtle conditional independencies
            'B = logistic(0,1)',
          'A = abs(B)**1.1 + logistic(0,.1)',
            'D = 1 * A + logistic(0,.1)',
          'C = .5 * abs(B)**1.1 + .5 * D + logistic(0,.1)',
            't = t + 1'
           ]
```

Result

getData: 10000 records read.

Testing expected independents:
dependence ('L1', 'L2') = 0.0
dependence ('L1', 'L2', ['A']) = 2.8778380009697457e-05
dependence ('L1', 'L2', ['A', 'B']) = 7.05532710032486e-09
dependence ('L2', 'L3') = 0.0
dependence ('L1', 'L3') = 0.0
dependence ('E1', 'E2') = 8.364596748577924e-08
dependence ('N1', 'N2') = 1.4488610311502725e-10
dependence ('L4', 'L5') = 3.2613619826427076e-05
dependence ('L5', 'L6') = 0.00021400946527339038
dependence ('L4', 'N3') = 0.0
dependence ('C', 'E2') = 0.0
dependence ('L6', 'L7', ['L3']) = 0.01727883384873441
dependence ('L4', 'L6', ['L3']) = 0.002908277945232851
dependence ('L8', 'L9', ['L1']) = 0.3851501969109814
dependence ('B', 'D', ['A']) = 4.829292432617649e-08
dependence ('A', 'C', ['B', 'D']) = 0.2182449421928021
dependence ('M1', 'E2') = 0.0
dependence ('M1', 'E2') = 0.0

Testing expected dependents:

dependence ('L3', 'L4') = 0.9999999999999234
dependence ('L5', 'L2') = 0.9999999999999923
dependence ('L6', 'L3') = 1.0000000000000153
dependence ('L6', 'L7') = 1.0000000000001226
dependence ('L7', 'L4') = 1.000000000000046
dependence ('E3', 'E1') = 1.0000000000000613
dependence ('E3', 'E2') = 1.0
dependence ('M1', 'N2') = 0.9999999999999617
dependence ('B', 'D') = 1.000000000000046
dependence ('B', 'D', 'C') = 0.9784949512753629
dependence ('B', 'D', ['A', 'C']) = 5.17420106760369e-10
dependence ('B', 'A', 'C') = 0.991891375830259
dependence ('B', 'A', ['C', 'D']) = 0.9999999925651529
dependence ('B', 'C', 'A') = 1.0
dependence ('A', 'C', 'B') = 1.0
dependence ('L8', 'L9') = 1.0000000000000153
dependence ('N1', 'N2', ['N3']) = 1.000000000000006
dependence ('N3', 'E1', ['M1']) = 1.000000000000015

dependence ('M1', 'E2', ['E3']) = 0.999999999999997

Maximum dependence for expected independents = 0.3851501969109814
Minimum dependence for expected dependents = 5.17420106760369e-10
Margin = -0.3851501963935613 . Positive margin is good.
Maximum dependence = 1.0000000000001226
best Low threshold is: 0.3861501969109814
best High threshold is: 1.1000000000001227

Test Time = 214