Evaluation of Quantum-Like Normal Form Approach

```
In[1]:= (* load quantum model *)
```

```
In[2]:= Get["/Users/162191/Documents/GitHub/quantum_international_interaction_game/
        Norm_Form/quantum_normal_form_model.m"];
```

Experiment 1: Testing on Imbalanced Dataset

Load Data

```
In[3]:= data = Import[
        "/Users/162191/Documents/GitHub/quantum_international_interaction_game/
          Norm_Form/first_dataset_with_SQ.csv",
        "CSV", "HeaderLines" → 1];
      dataset = Dataset[Association @@@
          (Rule @@@ Transpose[{{"Agent1", "Agent2", "wrTu1sq", "wrTu1ac1", "wrTu1ac2",
                "wrTu1neg", "wrTu1cp1", "wrTu1cp2", "wrTu1wr1", "wrTu1wr2",
                "wrTu2sq", "wrTu2ac2", "wrTu2ac1", "wrTu2neg", "wrTu2cp2",
                "wrTu2cp1", "wrTu2wr2", "wrTu2wr1", "groundtruth"}, #}] & /@ data)];

      preparedData = PrepareDataset[dataset];
```

Params

```
In[6]:= lambda = 1.0;
      maxIter = 200;
      threshold = 0.00001;
      verboseMode = False;
```

Searching for Optimal Params: Resampling over the full dataset with GridSize 5

```
In[10]:= optimalResult = FindOptimalPhases[preparedData, lambda,
        5, "RandomSampling", 750, maxIter, threshold, verboseMode];
      bestPhases = optimalResult["BestPhases"];
      Print[bestPhases];
      GetModelMetrics[preparedData, lambda, bestPhases]


      Using random sampling strategy with 750 samples
```

New best accuracy found: 0.0852197 (64 correct out of
 751) with phases: {2.31923, 3.81975, 4.17519, 3.73669}

New best accuracy found: 0.103862 (78 correct out of
 751) with phases: {5.15907, 0.330041, 0.22437, 5.31183}

New best accuracy found: 0.105193 (79 correct out of
 751) with phases: {1.59812, 5.60207, 1.51828, 0.600164}

New best accuracy found: 0.122503 (92 correct out of
 751) with phases: {0.232415, 6.11853, 3.63077, 5.70844}

New best accuracy found: 0.126498 (95 correct out of
 751) with phases: {2.46137, 2.09736, 3.13254, 2.80756}

Progress: 10% complete

Progress: 20% complete

Progress: 30% complete

Progress: 40% complete

Progress: 50% complete

Progress: 60% complete

Progress: 70% complete

Progress: 80% complete

New best accuracy found: 0.12783 (96 correct out of
 751) with phases: {4.82421, 5.36694, 3.28313, 2.56993}

Progress: 90% complete

Progress: 100% complete

{4.82421, 5.36694, 3.28313, 2.56993}

Model Performance with Phases: {4.82421, 5.36694, 3.28313, 2.56993}

Overall Performance Metrics:

Accuracy	0.1238
Macro-Average Precision	0.1064
Macro-Average Recall	0.0835
Macro-Average F1	0.0661
Weighted Average F1	0.1069

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	146	375	67	0.1787	0.4589	0.2572
Acq2	1	291	0	0	0	0.0000
Cap1	20	0	0	0.0000	0	0.0000
Cap2	174	0	0	0.0000	0	0.0000
Nego	28	0	0	0.0000	0	0.0000
SQ	253	52	20	0.3846	0.0791	0.1311
War1	129	33	6	0.1818	0.0465	0.0741

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Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	146	375	67	0.4589
Acq2	1	291	0	0
Cap1	20	0	0	0
Cap2	174	0	0	0
Nego	28	0	0	0
SQ	253	52	20	0.0791
War1	129	33	6	0.0465

Overall Accuracy: 0.1238

Searching for Optimal Params: Resampling over the full dataset with GridSize 10

```
In[14]:= optimalResult = FindOptimalPhases[preparedData, lambda,
    10, "RandomSampling", 750, maxIter, threshold, verboseMode];
bestPhases = optimalResult["BestPhases"];
Print[bestPhases];
GetModelMetrics[preparedData, lambda, bestPhases]
```

Using random sampling strategy with 750 samples

New best accuracy found: 0.0932091 (70 correct out of
  751) with phases: {5.60959, 4.79256, 1.80621, 1.81403}

New best accuracy found: 0.105193 (79 correct out of
  751) with phases: {2.92642, 6.10593, 1.6467, 6.21155}

New best accuracy found: 0.126498 (95 correct out of
  751) with phases: {2.83846, 0.0845882, 3.12186, 2.50178}

Progress: 10% complete

Progress: 20% complete

Progress: 30% complete

Progress: 40% complete

Progress: 50% complete

Progress: 60% complete

Progress: 70% complete

Progress: 80% complete

Progress: 90% complete

New best accuracy found: 0.142477 (107 correct out of
 751) with phases: {3.26678, 4.99591, 3.13928, 2.64279}

Progress: 100% complete

{3.26678, 4.99591, 3.13928, 2.64279}

Model Performance with Phases: {3.26678, 4.99591, 3.13928, 2.64279}

Overall Performance Metrics:

Accuracy	0.1252
Macro-Average Precision	0.0926
Macro-Average Recall	0.0917
Macro-Average F1	0.0702
Weighted Average F1	0.0982

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	146	389	67	0.1722	0.4589	0.2505
Acq2	1	251	0	0	0	0.0000
Cap1	20	0	0	0.0000	0	0.0000
Cap2	174	0	0	0.0000	0	0.0000
Nego	28	0	0	0.0000	0	0.0000
SQ	253	31	7	0.2258	0.0277	0.0493
War1	129	80	20	0.2500	0.1550	0.1914

Confusion Matrix Analysis:

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Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	146	389	67	0.4589
Acq2	1	251	0	0
Cap1	20	0	0	0
Cap2	174	0	0	0
Nego	28	0	0	0
SQ	253	31	7	0.0277
War1	129	80	20	0.1550

Overall Accuracy: 0.1252

Searching for Optimal Params: GridSearch over the full dataset Grid size 5

```
In[18]:= optimalResult = FindOptimalPhases[preparedData, lambda,
        5, "RandomSampling", 750, maxIter, threshold, verboseMode];
    bestPhases = optimalResult["BestPhases"];
    Print[bestPhases];
    GetModelMetrics[preparedData, lambda, bestPhases]
```

Using random sampling strategy with 750 samples

New best accuracy found: 0.0865513 (65 correct out of
  751) with phases: {4.88761, 3.63843, 1.80143, 0.482604}

New best accuracy found: 0.0985353 (74 correct out of
  751) with phases: {3.42786, 1.303, 3.84012, 4.1199}

New best accuracy found: 0.113182 (85 correct out of
  751) with phases: {4.51558, 1.04715, 3.95269, 5.67821}

New best accuracy found: 0.114514 (86 correct out of
  751) with phases: {2.07968, 0.727368, 2.49052, 0.325109}

New best accuracy found: 0.118509 (89 correct out of
  751) with phases: {4.41273, 5.007, 2.59261, 0.256207}

Progress: 10% complete

Progress: 20% complete

Progress: 30% complete

New best accuracy found: 0.125166 (94 correct out of
  751) with phases: {3.24962, 3.27434, 4.26249, 0.259473}

Progress: 40% complete

Progress: 50% complete

Progress: 60% complete

Progress: 70% complete

Progress: 80% complete

Progress: 90% complete

Progress: 100% complete

{3.24962, 3.27434, 4.26249, 0.259473}

Model Performance with Phases: {3.24962, 3.27434, 4.26249, 0.259473}

Overall Performance Metrics:

Accuracy	0.1292
Macro-Average Precision	0.1549
Macro-Average Recall	0.0943
Macro-Average F1	0.0906
Weighted Average F1	0.1294

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	146	260	48	0.1846	0.3288	0.2365
Acq2	1	224	0	0	0	0.0000
Cap1	20	15	0	0	0	0.0000
Cap2	174	50	4	0.0800	0.0230	0.0357
Nego	28	7	1	0.1429	0.0357	0.0571
SQ	253	35	18	0.5143	0.0711	0.1250
War1	129	160	26	0.1625	0.2016	0.1799

Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	146	260	48	0.3288
Acq2	1	224	0	0
Cap1	20	15	0	0
Cap2	174	50	4	0.0230
Nego	28	7	1	0.0357
SQ	253	35	18	0.0711
War1	129	160	26	0.2016

Overall Accuracy: 0.1292

Searching for Optimal Params: GridSearch over the full dataset Grid size 8

In[22]:= `optimalResult = FindOptimalPhases[preparedData, lambda, 8, "GridSearch"];`
`bestPhases = optimalResult["BestPhases"];`
`Print[bestPhases];`
`GetModelMetrics[preparedData, lambda, bestPhases]`

New best accuracy found: 0.105193 (79 correct out of 751) with phases: {0., 0., 0., 0.}

New best accuracy found: 0.109188 (82
   correct out of 751) with phases: {0., 0., 0.785398, 0.}

New best accuracy found: 0.117177 (88
   correct out of 751) with phases: {0., 0., 2.35619, 0.}

Progress: 5% complete

Progress: 10% complete

Progress: 15% complete

Progress: 20% complete

Progress: 25% complete

```
New best accuracy found: 0.118509 (89 correct out of
 751) with phases: {1.5708, 0., 3.14159, 0.785398}

Progress: 30% complete

Progress: 35% complete

Progress: 40% complete

Progress: 45% complete

Progress: 50% complete

Progress: 55% complete

New best accuracy found: 0.122503 (92
  correct out of 751) with phases: {3.14159, 3.14159, 0., 0.}

New best accuracy found: 0.123835 (93 correct out of
 751) with phases: {3.14159, 3.14159, 0.785398, 0.}

New best accuracy found: 0.12783 (96 correct out of
 751) with phases: {3.14159, 3.14159, 1.5708, 0.}

Progress: 60% complete

Progress: 65% complete

Progress: 70% complete

Progress: 75% complete

Progress: 80% complete

Progress: 85% complete

Progress: 90% complete

Progress: 95% complete

{3.14159, 3.14159, 1.5708, 0.}
```

Model Performance with Phases: {3.14159, 3.14159, 1.5708, 0.}

Overall Performance Metrics:

Accuracy	0.1278
Macro-Average Precision	0.1671
Macro-Average Recall	0.0894
Macro-Average F1	0.0881
Weighted Average F1	0.1353

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	146	235	42	0.1787	0.2877	0.2205
Acq2	1	262	0	0	0	0.0000
Cap1	20	22	0	0	0	0.0000
Cap2	174	21	6	0.2857	0.0345	0.0615
Nego	28	19	0	0	0	0.0000
SQ	253	35	18	0.5143	0.0711	0.1250
War1	129	157	30	0.1911	0.2326	0.2098

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Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	146	235	42	0.2877
Acq2	1	262	0	0
Cap1	20	22	0	0
Cap2	174	21	6	0.0345
Nego	28	19	0	0
SQ	253	35	18	0.0711
War1	129	157	30	0.2326

Overall Accuracy: 0.1278

Searching for Optimal Params: GridSearch over the full dataset Grid size 10

In[26]:= **optimalResult = FindOptimalPhases[preparedData, lambda, 10, "GridSearch"];**
bestPhases = optimalResult["BestPhases"];
Print[bestPhases];
GetModelMetrics[preparedData, lambda, bestPhases]

New best accuracy found: 0.105193 (79 correct out of 751) with phases: {0., 0., 0., 0.}

New best accuracy found: 0.107856 (81
  correct out of 751) with phases: {0., 0., 0.628319, 0.}

New best accuracy found: 0.118509 (89
  correct out of 751) with phases: {0., 0., 2.51327, 0.}

Progress: 5% complete

Progress: 10% complete

```
Progress: 15% complete

Progress: 20% complete

New best accuracy found: 0.122503 (92 correct out of
 751) with phases: {1.25664, 0.628319, 3.14159, 0.628319}

Progress: 25% complete

Progress: 30% complete

Progress: 35% complete

Progress: 40% complete

Progress: 45% complete

Progress: 50% complete

Progress: 55% complete

New best accuracy found: 0.125166 (94 correct out of
 751) with phases: {3.14159, 3.14159, 0.628319, 0.}

New best accuracy found: 0.129161 (97 correct out of
 751) with phases: {3.14159, 3.14159, 1.88496, 0.}

Progress: 60% complete

Progress: 65% complete

Progress: 70% complete

Progress: 75% complete

Progress: 80% complete

Progress: 85% complete

Progress: 90% complete

Progress: 95% complete

Progress: 100% complete

{3.14159, 3.14159, 1.88496, 0.}
```

Model Performance with Phases: {3.14159, 3.14159, 1.88496, 0.}

Overall Performance Metrics:

Accuracy	0.1292
Macro-Average Precision	0.1674
Macro-Average Recall	0.0903
Macro-Average F1	0.0883
Weighted Average F1	0.1354

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	146	252	44	0.1746	0.3014	0.2211
Acq2	1	259	0	0	0	0.0000
Cap1	20	18	0	0	0	0.0000
Cap2	174	21	6	0.2857	0.0345	0.0615
Nego	28	19	0	0	0	0.0000
SQ	253	35	18	0.5143	0.0711	0.1250
War1	129	147	29	0.1973	0.2248	0.2101

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Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	146	252	44	0.3014
Acq2	1	259	0	0
Cap1	20	18	0	0
Cap2	174	21	6	0.0345
Nego	28	19	0	0
SQ	253	35	18	0.0711
War1	129	147	29	0.2248

Overall Accuracy: 0.1292

Experiment 2: Testing on Balanced Dataset

```
data = Import[
   "/Users/162191/Documents/GitHub/quantum_international_interaction_game/
     Norm_Form/balanced_data.csv", "CSV", "HeaderLines" → 1];
dataset = Dataset[Association @@@
   (Rule @@@ Transpose[{{"Agent1", "Agent2" , "wrTu1sq", "wrTu1ac1", "wrTu1ac2",
        "wrTu1neg", "wrTu1cp1", "wrTu1cp2", "wrTu1wr1", "wrTu1wr2",
        "wrTu2sq", "wrTu2ac2", "wrTu2ac1", "wrTu2neg", "wrTu2cp2",
        "wrTu2cp1", "wrTu2wr2", "wrTu2wr1", "groundtruth"}, #}] & /@ data)];

preparedData = PrepareDataset[dataset];

Length[preparedData]
```

Out[33]=

579

Params

```
In[34]:=  lambda = 1.0;
          maxIter = 200;
          threshold = 0.000001;
          verboseMode = False;
```

Searching for Optimal Params: Resampling over the full dataset with GridSize 5

```
In[38]:=  optimalResult = FindOptimalPhases[preparedData, lambda,
              5, "RandomSampling", 750, maxIter, threshold, verboseMode];
          bestPhases = optimalResult["BestPhases"];
          Print[bestPhases];
          GetModelMetrics[preparedData, lambda, bestPhases]
```

```
Using random sampling strategy with 750 samples

New best accuracy found: 0.150259 (87 correct out of
 579) with phases: {5.08301, 5.48341, 0.765821, 3.0598}

New best accuracy found: 0.151986 (88 correct out of
 579) with phases: {4.21247, 3.06208, 6.12878, 0.389031}

New best accuracy found: 0.15544 (90 correct out of
 579) with phases: {4.86476, 1.05719, 4.65767, 5.34667}

New best accuracy found: 0.157168 (91 correct out of
 579) with phases: {6.15802, 2.95355, 0.897672, 4.16575}

New best accuracy found: 0.162349 (94 correct out of
 579) with phases: {5.09849, 4.38517, 0.298862, 2.34556}

Progress: 10% complete

Progress: 20% complete

Progress: 30% complete

Progress: 40% complete

Progress: 50% complete

New best accuracy found: 0.164076 (95 correct out of
 579) with phases: {3.42739, 2.95718, 6.18926, 5.59153}

Progress: 60% complete

Progress: 70% complete

Progress: 80% complete

Progress: 90% complete

Progress: 100% complete

{3.42739, 2.95718, 6.18926, 5.59153}
```

Model Performance with Phases: {3.42739, 2.95718, 6.18926, 5.59153}

Overall Performance Metrics:

Accuracy	0.1416
Macro-Average Precision	0.1739
Macro-Average Recall	0.1260
Macro-Average F1	0.0936
Weighted Average F1	0.1210

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	6	138	1	0.0072	0.1667	0.0139
Acq2	99	219	39	0.1781	0.3939	0.2453
Cap1	56	36	3	0.0833	0.0536	0.0652
Cap2	99	13	3	0.2308	0.0303	0.0536
Nego	99	2	1	0.5000	0.0101	0.0198
SQ	99	45	8	0.1778	0.0808	0.1111
War1	99	126	27	0.2143	0.2727	0.2400
War2	22	0	0	0.0000	0	0.0000

Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	6	138	1	0.1667
Acq2	99	219	39	0.3939
Cap1	56	36	3	0.0536
Cap2	99	13	3	0.0303
Nego	99	2	1	0.0101
SQ	99	45	8	0.0808
War1	99	126	27	0.2727
War2	22	0	0	0

Overall Accuracy: 0.1416

Searching for Optimal Params: Resampling over the full dataset with GridSize 10

```
In[42]:= optimalResult = FindOptimalPhases[preparedData, lambda,
          10, "RandomSampling", 750, maxIter, threshold, verboseMode];
      bestPhases = optimalResult["BestPhases"];
      Print[bestPhases];
      GetModelMetrics[preparedData, lambda, bestPhases]
```

Using random sampling strategy with 750 samples

New best accuracy found: 0.15544 (90 correct out of
 579) with phases: {0.614632, 2.9642, 5.96466, 5.91514}

New best accuracy found: 0.160622 (93 correct out of
 579) with phases: {0.808205, 3.57066, 1.2317, 0.275203}

Progress: 10% complete

New best accuracy found: 0.162349 (94 correct out of
 579) with phases: {0.274793, 3.55653, 6.01048, 0.177543}

Progress: 20% complete

Progress: 30% complete

Progress: 40% complete

Progress: 50% complete

Progress: 60% complete

Progress: 70% complete

Progress: 80% complete

Progress: 90% complete

Progress: 100% complete

{0.274793, 3.55653, 6.01048, 0.177543}

Model Performance with Phases: {0.274793, 3.55653, 6.01048, 0.177543}

Overall Performance Metrics:

Accuracy	0.1623
Macro-Average Precision	0.0771
Macro-Average Recall	0.1383
Macro-Average F1	0.0835
Weighted Average F1	0.1119

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	6	137	1	0.0073	0.1667	0.0140
Acq2	99	292	62	0.2123	0.6263	0.3171
Cap1	56	0	0	0.0000	0	0.0000
Cap2	99	0	0	0.0000	0	0.0000
Nego	99	0	0	0.0000	0	0.0000
SQ	99	45	8	0.1778	0.0808	0.1111
War1	99	105	23	0.2190	0.2323	0.2255
War2	22	0	0	0.0000	0	0.0000

Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	6	137	1	0.1667
Acq2	99	292	62	0.6263
Cap1	56	0	0	0
Cap2	99	0	0	0
Nego	99	0	0	0
SQ	99	45	8	0.0808
War1	99	105	23	0.2323
War2	22	0	0	0

Overall Accuracy: 0.1623

Searching for Optimal Params: GridSearch over the full dataset Grid size 5

```
In[46]:= optimalResult = FindOptimalPhases[preparedData, lambda,
        5, "RandomSampling", 750, maxIter, threshold, verboseMode];
    bestPhases = optimalResult["BestPhases"];
    Print[bestPhases];
    GetModelMetrics[preparedData, lambda, bestPhases]
```

Using random sampling strategy with 750 samples

New best accuracy found: 0.141623 (82 correct out of
 579) with phases: {3.77791, 2.85149, 2.38587, 4.61835}

New best accuracy found: 0.153713 (89 correct out of
 579) with phases: {0.837654, 0.333739, 1.68179, 6.07938}

New best accuracy found: 0.15544 (90 correct out of
 579) with phases: {0.123021, 4.35852, 0.882964, 6.1144}

New best accuracy found: 0.157168 (91 correct out of
 579) with phases: {0.269761, 0.813548, 0.779302, 0.982712}

New best accuracy found: 0.160622 (93 correct out of
 579) with phases: {5.4292, 0.388183, 5.67498, 3.90001}

New best accuracy found: 0.162349 (94 correct out of
 579) with phases: {5.17356, 1.93027, 0.591109, 3.90833}

Progress: 10% complete

Progress: 20% complete

Progress: 30% complete

Progress: 40% complete

Progress: 50% complete

Progress: 60% complete

Progress: 70% complete

Progress: 80% complete

Progress: 90% complete

Progress: 100% complete

{5.17356, 1.93027, 0.591109, 3.90833}

Model Performance with Phases: {5.17356, 1.93027, 0.591109, 3.90833}

Overall Performance Metrics:

Accuracy	0.1623
Macro-Average Precision	0.0742
Macro-Average Recall	0.1383
Macro-Average F1	0.0791
Weighted Average F1	0.1057

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	6	126	1	0.0079	0.1667	0.0152
Acq2	99	320	68	0.2125	0.6869	0.3246
Cap1	56	0	0	0.0000	0	0.0000
Cap2	99	0	0	0.0000	0	0.0000
Nego	99	0	0	0.0000	0	0.0000
SQ	99	44	8	0.1818	0.0808	0.1119
War1	99	89	17	0.1910	0.1717	0.1809
War2	22	0	0	0.0000	0	0.0000

Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	6	126	1	0.1667
Acq2	99	320	68	0.6869
Cap1	56	0	0	0
Cap2	99	0	0	0
Nego	99	0	0	0
SQ	99	44	8	0.0808
War1	99	89	17	0.1717
War2	22	0	0	0

Overall Accuracy: 0.1623

Searching for Optimal Params: GridSearch over the full dataset Grid size 8

```
In[50]:= optimalResult = FindOptimalPhases[preparedData, lambda, 8, "GridSearch"];
bestPhases = optimalResult["BestPhases"];
Print[bestPhases];
GetModelMetrics[preparedData, lambda, bestPhases]
```

New best accuracy found: 0.153713 (89 correct out of 579) with phases: {0., 0., 0., 0.}

New best accuracy found: 0.160622 (93
  correct out of 579) with phases: {0., 0., 0., 2.35619}

New best accuracy found: 0.162349 (94
  correct out of 579) with phases: {0., 0., 0.785398, 2.35619}

Progress: 5% complete

Progress: 10% complete

Progress: 15% complete

```
Progress: 20% complete
Progress: 25% complete
Progress: 30% complete
Progress: 35% complete
Progress: 40% complete
Progress: 45% complete
Progress: 50% complete
Progress: 55% complete
Progress: 60% complete
Progress: 65% complete
Progress: 70% complete
Progress: 75% complete
Progress: 80% complete
Progress: 85% complete
Progress: 90% complete
Progress: 95% complete
{0., 0., 0.785398, 2.35619}
```

Model Performance with Phases: {0., 0., 0.785398, 2.35619}

Overall Performance Metrics:

Accuracy	0.1623
Macro-Average Precision	0.0732
Macro-Average Recall	0.1383
Macro-Average F1	0.0789
Weighted Average F1	0.1056

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	6	126	1	0.0079	0.1667	0.0152
Acq2	99	314	68	0.2166	0.6869	0.3293
Cap1	56	0	0	0.0000	0	0.0000
Cap2	99	0	0	0.0000	0	0.0000
Nego	99	0	0	0.0000	0	0.0000
SQ	99	44	8	0.1818	0.0808	0.1119
War1	99	95	17	0.1789	0.1717	0.1753
War2	22	0	0	0.0000	0	0.0000

Confusion Matrix Analysis:

□

Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	6	126	1	0.1667
Acq2	99	314	68	0.6869
Cap1	56	0	0	0
Cap2	99	0	0	0
Nego	99	0	0	0
SQ	99	44	8	0.0808
War1	99	95	17	0.1717
War2	22	0	0	0

Overall Accuracy: 0.1623

Searching for Optimal Params: GridSearch over the full dataset Grid size 10

In[54]:= ```
optimalResult = FindOptimalPhases[preparedData, lambda, 10, "GridSearch"];
bestPhases = optimalResult["BestPhases"];
Print[bestPhases];
GetModelMetrics[preparedData, lambda, bestPhases]
```

New best accuracy found: 0.153713 (89 correct out of 579) with phases: {0., 0., 0., 0.}

New best accuracy found: 0.158895 (92
correct out of 579) with phases: {0., 0., 0., 1.25664}

Progress: 5% complete

Progress: 10% complete

Progress: 15% complete

```
Progress: 20% complete
Progress: 25% complete
Progress: 30% complete
Progress: 35% complete
Progress: 40% complete
Progress: 45% complete
Progress: 50% complete
Progress: 55% complete
Progress: 60% complete
Progress: 65% complete
Progress: 70% complete
Progress: 75% complete
Progress: 80% complete
Progress: 85% complete
Progress: 90% complete
Progress: 95% complete
Progress: 100% complete
{0., 0., 0., 1.25664}
```

Model Performance with Phases: {0., 0., 0., 1.25664}

Overall Performance Metrics:

Accuracy	0.1589
Macro-Average Precision	0.0734
Macro-Average Recall	0.1162
Macro-Average F1	0.0820
Weighted Average F1	0.1122

Performance by Outcome Category:

Category	Actual	Predicted	Correct	Precision	Recall	F1 Score
Acq1	6	133	0	0	0	0.0000
Acq2	99	251	56	0.2231	0.5657	0.3200
Cap1	56	0	0	0.0000	0	0.0000
Cap2	99	0	0	0.0000	0	0.0000
Nego	99	0	0	0.0000	0	0.0000
SQ	99	45	8	0.1778	0.0808	0.1111
War1	99	150	28	0.1867	0.2828	0.2249
War2	22	0	0	0.0000	0	0.0000

Category	Actual Count	Predicted Count	Correct	Accuracy
Acq1	6	133	0	0
Acq2	99	251	56	0.5657
Cap1	56	0	0	0
Cap2	99	0	0	0
Nego	99	0	0	0
SQ	99	45	8	0.0808
War1	99	150	28	0.2828
War2	22	0	0	0

Overall Accuracy: 0.1589