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| --- | --- |
| 實驗目標 | |
| **實驗一** | |
| TAIEX | 2001前十個月為訓練資料，剩餘為測試資料 |
| **實驗二** | |
| TAIEX | 2000前十個月為訓練資料，剩餘為測試資料 |
| HSI | 2000前十個月為訓練資料，剩餘為測試資料 |
| **實驗三** | |
| TAIEX | 2001前十個月為訓練資料，剩餘為測試資料 |
| DJI | 2001前十個月為訓練資料，剩餘為測試資料 |
| NASDAQ | 2001前十個月為訓練資料，剩餘為測試資料 |
| S&P500 | 2001前十個月為訓練資料，剩餘為測試資料 |

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| 機器學習參數設定 | |
| **PSO** | |
| 粒子群大小 | 50 |
| 迭代次數 | 100 |
|  | {0.8, 2.0, 2.0} |
|  | Random in [0,1] |
| 粒子初始化位置 | 藉由第三章所提SC演算法決定 |
| 粒子初始化速度 | 0 |
| **ABCO** | |
| 工蜂數量 | 40 |
| 觀察蜂數量 | 10 |
| 迭代次數 | 100 |
| 限制回合數 | 20 |
| **RLSE** | |
|  |  |
|  | *D*-by-1 全零向量 |
|  | I |
| I | *D*-by-*D* 單位矩陣 |
| *D* | 後鑑部參數數目 |

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| 實驗一 | |
| 方法 | TAIEX |
| Chen [38] | 167 |
| Yu [38] | 148 |
| AR(1) [38] | 115 |
| SVR [38] | 114 |
| ANFIS [38] | 120 |
| Wei [38] | 110 |
| PSO-RLSE (proposed) | 102.01 |
| ABCO-RLSE (proposed) | **101.93** |

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| 實驗二 | | |
| 方法 | TAIEX | HSI |
| Chen [6] | 413.27 | 280.15 |
| Yu [6] | 419.64 | 297.05 |
| SR+ANFIS [6] | 454.63 | 356.70 |
| SR+SVR [6] | 255.87 | 356.81 |
| Elman [6] | 154.21 | 302.27 |
| Cheng [6] | **150.55** | 251.70 |
| PSO-RLSE (proposed) | 151.06 | 254.97 |
| ABCO-RLSE (proposed) | 153.45 | **250.51** |

|  |  |  |
| --- | --- | --- |
| 實驗三 | | |
| 方法 | TAIEX | DJI |
| SVR (two models, each with single output) [27] | 162.46 | 101.44 |
| ANFIS (two models, each with single output) [27] | 147.36 | 105.56 |
| ANFIS (one model with two outputs) [27] | 151.62 | 128.20 |
| RBF (two models, each with single output) [27] | 134.32 | 106.33 |
| RBF (one model with two outputs) [27] | 137.58 | 181.79 |
| CNFS(5)-ARIMA (one model with two outputs) [27] | 115.82 | 103.06 |
| PSO-RLSE (proposed) | **101.61** | 101.82 |
| ABCO-RLSE (proposed) | 102.61 | **100.79** |

實驗一

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Chen [38] | Yu [38] | AR(1) [38] | SVR [38] | ANFIS [38] | Wei [38] | PSO-RLSE | ABCO-RLSE |
| Best | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.052 | 0.027 |
| 利潤(TAIEX) | -92 | -73 | 671 | 202 | 686 | 795 | **990.76** | 790.05 |

實驗二

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Chen [6] | Yu  [6] | SR+ANFIS [6] | SR+SVR [6] | Elman [6] | Cheng et al. [6] | PSO-RLSE | ABCO-RLSE |
| Best | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.029 | 0.073 |
| 利潤(TAIEX) | 0 | 0 | 0 | 0 | 0 | -231.02 | **1367.8** | 922.95 |
| 利潤(HSI) | -1471 | -1368 | -602.94 | 190.71 | 2342 | 1793.12 | **2393.1** | 1139.4 |

實驗三

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Chen [38] | Yu [38] | AR(1) [38] | SVR [38] | ANFIS [38] | Wei [38] | PSO-RLSE | ABCO-RLSE |
| Best | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.049 | 0.049 |
| 利潤(TAIEX) | -92 | -73 | 671 | 202 | 686 | 795 | 1104.6 | **1409.9** |

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| 十次重複實驗效能統計(實驗一) | | |
| Trials | PSO-RLSE | ABCO-RLSE |
| 1 | 102.33 | 102.94 |
| 2 | 102.17 | 105.22 |
| 3 | 104.88 | 102.69 |
| 4 | 102.69 | 102.75 |
| 5 | 102.96 | **101.93** |
| 6 | **102.01** | 102.97 |
| 7 | 103.17 | 103.15 |
| 8 | 117.92 | 103.01 |
| 9 | 102.54 | 104.63 |
| 10 | 103.96 | 106.87 |

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| 模擬投資利潤表(實驗一) | | | | | | | | |
| Trials | PSO-RLSE | | ABCO-RLSE | | PSO-RLSE\* | | ABCO-RLSE\* | |
| 利潤 | | 利潤 | | 利潤 | | 利潤 | |
| Best | 0.052 | | 0.027 | | 0.057 | | 0.048 | |
| 1 | **990.76** |  | -430.77 |  | 0 |  | **0** |  |
| 2 | 698.90 |  | -484.46 |  | 102.42 |  | -25.62 |  |
| 3 | -1.7452 |  | -700.05 |  | **205.99** |  | 0 |  |
| 4 | -826.35 |  | **790.05** |  | -86.05 |  | 0 |  |
| 5 | 235.74 |  | 666.28 |  | 0 |  | **187.81** |  |
| 6 | 283.94 |  | 490.75 |  | 102.01 |  | 108.23 |  |
| 7 | -356.82 |  | 207.13 |  | 161.61 |  | 12.12 |  |
| 8 | 465.34 |  | 530.23 |  | -21.53 |  | 82.03 |  |
| 9 | 152.48 |  | -382.58 |  | 12.12 |  | -21.53 |  |
| 10 | -713.04 |  | 145.88 |  | 188.41 |  | 80.18 |  |
| 平均 | -81.43 | | 83.24 | | 66.49 | | 42.32 | |
| 標準差 | 826.24 | | 541.78 | | 99.29 | | 69.52 | |

\*改良的投資策略

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| 模擬投資利潤表(實驗一, 窗格算法) | | | | | | | | |
| Trials | PSO-RLSE | | | | ABCO-RLSE | | | |
| Interval | 5 | 10 | 20 | 30 | 5 | 10 | 20 | 30 |
| Best | 0.019 | 0.056 | 0.001 | 0.056 | 0.048 | 0.009 | 0.048 | 0.048 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 257.02 | 0 | 257.02 | 0 | 0 | 0 | 0 |
| 3 | 0 | **431.17** | 0 | **431.17** | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | **177.02** | **269.14** | **704.83** | **269.14** |
| 6 | 102.01 | 161.69 | 0 | 9.18 | 82.03 | 0 | 609.84 | 174.15 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 82.03 | 0 | 609.84 | 174.15 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 59.69 | 0 | 226.43 | 0 | 0 | 0 | 0 |
| 平均 | 10.2 | 90.96 | 0 | **92.38** | 34.11 | 26.91 | **192.45** | 61.74 |
| 標準差 | 32.26 | 148.68 | 0 | 155.63 | 60.7 | 85.11 | 310.95 | 102.72 |

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| 十次重複實驗效能統計(實驗二) | | |
| Trials | PSO-RLSE | ABCO-RLSE |
| 1 | 298.49 | 296.49 |
| 2 | **296.36** | 304.76 |
| 3 | 302.48 | 296.26 |
| 4 | 298.20 | 296.25 |
| 5 | 305.08 | 296.59 |
| 6 | 332.39 | **293.77** |
| 7 | 308.42 | 314.39 |
| 8 | 303.56 | 295.34 |
| 9 | 297.36 | 297.58 |
| 10 | 329.41 | 307.30 |

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| 模擬投資利潤表(實驗二) | | | | | | | | |
| Trials | PSO-RLSE | | ABCO-RLSE | | PSO-RLSE\* | | ABCO-RLSE\* | |
| 利潤 | | 利潤 | | 利潤 | | 利潤 | |
| Best | 0.029 | | 0.073 | | 0.047 | | 0.011 | |
| 1 | -127.26 |  | -1540.7 |  | 167.42 |  | 128.39 |  |
| 2 | -1712.9 |  | **2062.4** |  | 122.46 |  | 35.49 |  |
| 3 | -2726.6 |  | -1337 |  | 166.24 |  | -61.21 |  |
| 4 | -2022.7 |  | -822.64 |  | 62.53 |  | -143.9 |  |
| 5 | 909.16 |  | 814.5 |  | 515.98 |  | **285.72** |  |
| 6 | -969.99 |  | -1902.1 |  | 500.97 |  | -209.4 |  |
| 7 | 1453.9 |  | 163.68 |  | 25.05 |  | 149.63 |  |
| 8 | -2712.9 |  | 665.28 |  | 66.42 |  | -95.68 |  |
| 9 | **2515.3** |  | -1274 |  | **800.26** |  | 128.39 |  |
| 10 | -826.09 |  | -941.3 |  | -121.6 |  | 202.16 |  |
| 平均 | -622 | | -411.17 | | 230.57 | | 41.95 | |
| 標準差 | 1790 | | 1276.3 | | 282.92 | | 162.95 | |

\*改良的投資策略

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| 模擬投資利潤表(實驗二, 窗格算法) | | | | | | | | |
| Trials | PSO-RLSE | | | | ABCO-RLSE | | | |
| Interval | 5 | 10 | 20 | 30 | 5 | 10 | 20 | 30 |
| Best | 0.023 | 0.024 | 0.098 | 0.015 | 0.001 | 0.001 | 0.002 | 0.002 |
| 1 | -1193.2 | 107.19 | -134.67 | 0 | 0 | 0 | 0 | 0 |
| 2 | **0** | 0 | -134.67 | 0 | 0 | 0 | 0 | 0 |
| 3 | -843.06 | 234.63 | -1862 | 0 | 0 | 0 | 0 | 0 |
| 4 | -872.94 | 0 | -903.95 | 0 | 0 | 0 | 0 | 0 |
| 5 | -320.28 | 107.19 | -1989 | 0 | 0 | 0 | 0 | 0 |
| 6 | -342.88 | 84.59 | -769.3 | 0 | 0 | 0 | 0 | 0 |
| 7 | -342.88 | 84.59 | -157.12 | 0 | 0 | 0 | 0 | 0 |
| 8 | -843.06 | **234.63** | -3120.3 | 0 | 0 | 0 | 0 | 0 |
| 9 | -171.44 | 42.29 | **0** | 0 | 0 | 0 | 0 | 0 |
| 10 | -756.75 | 107.19 | 0 | 0 | 0 | 0 | 0 | 0 |
| 平均 | -568.65 | **100.24** | -907.14 | 0 | 0 | 0 | 0 | 0 |
| 標準差 | 382.02 | 81.79 | 1075.1 | 0 | 0 | 0 | 0 | 0 |

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| --- | --- | --- |
| 十次重複實驗效能統計(實驗三) | | |
| Trials | PSO-RLSE | ABCO-RLSE |
| 1 | 185.99 | 199.32 |
| 2 | 183.75 | 183.89 |
| 3 | 183.72 | 204.56 |
| 4 | 183.81 | 256.10 |
| 5 | 184.39 | **180.82** |
| 6 | 191.31 | 199.00 |
| 7 | **181.90** | 217.09 |
| 8 | 281.103 | 182.13 |
| 9 | 183.68 | 188.24 |
| 10 | 183.67 | 183.89 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 模擬投資利潤表(實驗三) | | | | | | | | |
| Trials | PSO-RLSE | | ABCO-RLSE | | PSO-RLSE\* | | ABCO-RLSE\* | |
| 利潤 | | 利潤 | | 利潤 | | 利潤 | |
| Best | 0.049 | | 0.049 | | 0.059 | | 0.025 | |
| 1 | -444.90 |  | 942.69 |  | 341.79 |  | **951.12** |  |
| 2 | 615.12 |  | 1206 |  | 0 |  | 266.13 |  |
| 3 | 880.74 |  | -850.1 |  | 52.399 |  | -139.9 |  |
| 4 | -1629.7 |  | 67.36 |  | 0 |  | 352.73 |  |
| 5 | -365.89 |  | **3201.7** |  | 149.49 |  | 682.72 |  |
| 6 | 762.83 |  | 1374.9 |  | **740.06** |  | 141.16 |  |
| 7 | **2146.7** |  | 2156.9 |  | 80.34 |  | 149.49 |  |
| 8 | -805.41 |  | 784.34 |  | 310.11 |  | 410.97 |  |
| 9 | -1741.7 |  | 3460.7 |  | 0 |  | 324.16 |  |
| 10 | -1189.6 |  | 1206 |  | 0 |  | 266.13 |  |
| 平均 | -177.19 | | **1355.1** | | **167.42** | | 340.47 | |
| 標準差 | 1252.4 | | 1314 | | **238.49** | | **300.64** | |

\*改良的投資策略

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 模擬投資利潤表(實驗三, 窗格算法) | | | | | | | | |
| Trials | PSO-RLSE | | | | ABCO-RLSE | | | |
| Interval | 5 | 10 | 20 | 30 | 5 | 10 | 20 | 30 |
| Best | 0.022 | 0.022 | 0.017 | 0.064 | 0.006 | 0.006 | 0.05 | 0.022 |
| 1 | **457.97** | **1225.6** | 325.31 | 140.61 | 0 | 0 | 1837.7 | 602.43 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1724.5 | 658.46 |
| 3 | 354.04 | 538.28 | **1409.7** | **1159.8** | 177.02 | 269.14 | 1760.4 | 453.38 |
| 4 | 0 | 0 | 0 | 0 | 48.85 | 48.85 | 1704.2 | 397.15 |
| 5 | 0 | 0 | 0 | 107.53 | 0 | **0** | **2292.7** | 618.23 |
| 6 | 280.44 | 955.11 | 325.31 | 364.55 | 412.09 | 471.78 | 471.78 | 619.26 |
| 7 | 150.82 | 242.94 | 678.63 | 496.28 | 0 | 0 | 119.82 | 0 |
| 8 | 0 | 0 | 0 | 0 | 410.98 | **1760.3** | 650.62 | 0 |
| 9 | 0 | 0 | 0 | 0 | **766.13** | 1010.1 | 1881.4 | **857.54** |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1724.5 | 658.46 |
| 平均 | 124.33 | **296.19** | 273.89 | 226.88 | 181.51 | 356.01 | **1416.8** | 456.49 |
| 標準差 | 176.98 | 457.74 | 460.58 | 371.34 | 264.57 | 591.50 | 723.62 | 284.61 |

結論一:本研究模型效能表現較佳

結論二:本研究使用比較文獻的方法計算利潤，效果較好

結論三:本研究提出的方法可以使得十次投資的標準差下降，平均仍維持正值，使得投資在有賺錢的情況下，降低風險。

結論四:本研究提出的計算利潤方法(窗格)，較為貼近真實操作狀況。透過實驗可看出不同模型的最佳窗格區間皆有所不同。