Supplementary file : tuning parameters

UBiRW five-fold multi-column zeroing cross-validation on yeast dataset

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process | r | l | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| UBiRW | MF | 1 | 1 | 0.301788 | 0.820967 | 0.313873 | 0.667357 | 0.179383 |
| UBiRW | MF | 2 | 1 | 0.361337 | 0.826088 | 0.382433 | 0.790725 | 0.218985 |
| UBiRW | MF | 2 | 2 | 0.35388 | 0.815345 | 0.372551 | 0.77995 | 0.213887 |
| UBiRW | MF | 3 | 1 | **0.365524** | **0.829732** | **0.38712** | **0.80713** | **0.224621** |
| UBiRW | MF | 3 | 2 | 0.362314 | 0.810975 | 0.381008 | 0.794301 | 0.221825 |
| UBiRW | MF | 3 | 3 | 0.348778 | 0.783146 | 0.360158 | 0.776102 | 0.206038 |
| UBiRW | MF | 4 | 1 | 0.273314 | 0.812196 | 0.29699 | 0.77178 | 0.159416 |
| UBiRW | MF | 4 | 2 | 0.273314 | 0.77408 | 0.296027 | 0.756629 | 0.157011 |
| UBiRW | MF | 4 | 3 | 0.26153 | 0.710411 | 0.260144 | 0.70528 | 0.123328 |
| UBiRW | MF | 4 | 4 | 0.230285 | 0.704138 | 0.221143 | 0.676997 | 0.095753 |
| UBiRW | CC | 1 | 1 | 0.434188 | 0.839337 | 0.437308 | 0.670342 | 0.29221 |
| UBiRW | CC | 2 | 1 | **0.488544** | **0.865213** | **0.502784** | 0.838695 | **0.330757** |
| UBiRW | CC | 2 | 2 | 0.48537 | 0.860764 | 0.498879 | 0.833937 | 0.329061 |
| UBiRW | CC | 3 | 1 | 0.460831 | 0.856346 | 0.480901 | **0.853863** | 0.309152 |
| UBiRW | CC | 3 | 2 | 0.470181 | 0.855459 | 0.489127 | 0.844119 | 0.319194 |
| UBiRW | CC | 3 | 3 | 0.462257 | 0.845736 | 0.479407 | 0.834201 | 0.312842 |
| UBiRW | CC | 4 | 1 | 0.372148 | 0.83325 | 0.395376 | 0.829246 | 0.242372 |
| UBiRW | CC | 4 | 2 | 0.383395 | 0.81693 | 0.405541 | 0.818088 | 0.251819 |
| UBiRW | CC | 4 | 3 | 0.262341 | 0.742655 | 0.257126 | 0.677878 | 0.135054 |
| UBiRW | BP | 1 | 1 | 0.347108 | 0.721866 | 0.343112 | 0.702249 | 0.228939 |
| UBiRW | BP | 2 | 1 | **0.385796** | **0.758174** | **0.383878** | 0.788022 | **0.257479** |
| UBiRW | BP | 2 | 2 | 0.380573 | 0.755898 | 0.378604 | 0.777126 | 0.253947 |
| UBiRW | BP | 1 | 2 | 0.112966 | 0.667949 | 0.130658 | 0.582277 | 0.04746 |
| UBiRW | BP | 3 | 1 | 0.368078 | 0.740931 | 0.366746 | **0.805719** | 0.24 |
| UBiRW | BP | 3 | 2 | 0.365943 | 0.726015 | 0.360162 | 0.786626 | 0.23548 |
| UBiRW | BP | 3 | 3 | 0.352721 | 0.700802 | 0.333938 | 0.763722 | 0.211761 |
| UBiRW | BP | 4 | 1 | 0.285436 | 0.725758 | 0.289225 | 0.772865 | 0.176187 |
| UBiRW | BP | 4 | 2 | 0.287394 | 0.691186 | 0.28261 | 0.746707 | 0.173188 |

UBiRW two-fold multi-column zeroing cross-validation on human dataset

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process | r | l | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| UBiRW | MF | 1 | 1 | 0.2426 | 0.8191 | 0.249 | 0.6176 | 0.1175 |
| UBiRW | MF | 2 | 1 | 0.2982 | 0.8087 | 0.3198 | 0.8562 | 0.1472 |
| UBiRW | MF | 1 | 2 | 0.0371 | **0.8479** | 0.0468 | 0.535 | 0.015 |
| UBiRW | MF | 2 | 2 | 0.2922 | 0.8081 | 0.3137 | 0.8449 | 0.144 |
| UBiRW | MF | 3 | 1 | 0.3534 | 0.8014 | 0.3681 | **0.8721** | 0.1752 |
| UBiRW | MF | 3 | 2 | **0.3564** | 0.7997 | **0.3686** | 0.8587 | **0.1755** |
| UBiRW | MF | 3 | 3 | 0.3508 | 0.796 | 0.36 | 0.8407 | 0.1702 |
| UBiRW | MF | 4 | 1 | 0.2172 | 0.7884 | 0.2377 | 0.8299 | 0.1008 |
| UBiRW | MF | 4 | 2 | 0.2224 | 0.7847 | 0.2415 | 0.8037 | 0.1026 |
| UBiRW | MF | 4 | 3 | 0.1727 | 0.7934 | 0.1819 | 0.7052 | 0.0738 |
| UBiRW | CC | 1 | 1 | 0.3525 | **0.8317** | 0.3568 | 0.6922 | 0.1757 |
| UBiRW | CC | 2 | 1 | **0.3976** | 0.8206 | **0.4139** | 0.8713 | **0.2015** |
| UBiRW | CC | 1 | 2 | 0.0667 | 0.8245 | 0.0867 | 0.6278 | 0.0279 |
| UBiRW | CC | 2 | 2 | 0.3961 | 0.8215 | 0.4123 | 0.8621 | 0.2012 |
| UBiRW | CC | 3 | 1 | 0.3833 | 0.8195 | 0.4025 | **0.883** | 0.1935 |
| UBiRW | CC | 3 | 2 | 0.3916 | 0.817 | 0.4091 | 0.8733 | 0.1977 |
| UBiRW | CC | 3 | 3 | 0.3853 | 0.8153 | 0.4024 | 0.8584 | 0.1936 |
| UBiRW | CC | 4 | 1 | 0.2848 | 0.8047 | 0.3056 | 0.8558 | 0.1363 |
| UBiRW | CC | 4 | 2 | 0.2884 | 0.8031 | 0.3093 | 0.8359 | 0.1387 |
| UBiRW | CC | 4 | 3 | 0.2329 | 0.807 | 0.2449 | 0.7184 | 0.1067 |
| UBiRW | BP | 1 | 1 | 0.4172 | 0.6455 | 0.366 | 0.7315 | 0.2375 |
| UBiRW | BP | 2 | 1 | **0.458** | 0.6631 | **0.4089** | 0.8612 | **0.2643** |
| UBiRW | BP | 2 | 2 | 0.4564 | 0.6617 | 0.4071 | 0.853 | 0.2633 |
| UBiRW | BP | 3 | 1 | 0.4088 | 0.6572 | 0.3791 | **0.873** | 0.2382 |
| UBiRW | BP | 3 | 2 | 0.4079 | 0.6459 | 0.3769 | 0.8523 | 0.2388 |
| UBiRW | BP | 3 | 3 | 0.3983 | 0.6345 | 0.3632 | 0.8333 | 0.2297 |
| UBiRW | BP | 4 | 1 | 0.2735 | 0.6333 | 0.2579 | 0.8326 | 0.1531 |
| UBiRW | BP | 4 | 2 | 0.2784 | 0.6176 | 0.2568 | 0.7926 | 0.1558 |
| UBiRW | BP | 4 | 3 | 0.185 | 0.5679 | 0.1577 | 0.6749 | 0.0847 |

PONMF-S1 five-fold multi-column zeroing cross-validation on yeast dataset

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  |  | | , | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| PONMF-S1 | MF | 10 | | 0.001 | 0.2 | 0.159551 | 0.747478 | 0.174898 | 0.692195 | 0.070773 |
| PONMF-S1 | MF | 1 | | 0.001 | 0.2 | 0.360960 | 0.828695 | 0.382379 | 0.813221 | 0.225607 |
| PONMF-S1 | MF | 0.1 | | 0.001 | 0.2 | 0.384782 | 0.845664 | 0.405533 | 0.816907 | 0.241612 |
| PONMF-S1 | MF | 0.01 | | 0.001 | 0.2 | **0.387775** | 0.848675 | **0.407888** | 0.812190 | 0.242914 |
| PONMF-S1 | MF | 0.001 | | 0.01 | 0.2 | 0.386839 | **0.849260** | 0.407239 | 0.807342 | **0.243074** |
| PONMF-S1 | MF | 0.11 | | 0.001 | 0.2 | 0.383740 | 0.844305 | 0.404594 | 0.816214 | 0.240901 |
| PONMF-S1 | MF | 0.13 | | 0.001 | 0.2 | 0.383483 | 0.843631 | 0.404358 | 0.816750 | 0.240649 |
| PONMF-S1 | MF | 0.15 | | 0.001 | 0.2 | 0.381769 | 0.843683 | 0.402616 | 0.816117 | 0.240040 |
| PONMF-S1 | MF | 0.17 | | 0.001 | 0.2 | 0.381392 | 0.842781 | 0.402004 | 0.816023 | 0.239250 |
| PONMF-S1 | MF | 0.18 | | 0.001 | 0.2 | 0.381106 | 0.843052 | 0.402061 | 0.816699 | 0.239401 |
| PONMF-S1 | MF | 0.19 | | 0.001 | 0.2 | 0.381374 | 0.843184 | 0.402685 | 0.817080 | 0.239968 |
| PONMF-S1 | MF | 0.18 | | 0.0001 | 0.2 | 0.382243 | 0.844358 | 0.403189 | 0.816082 | 0.240172 |
| PONMF-S1 | MF | 0.18 | | 0.0002 | 0.2 | 0.382999 | 0.843092 | 0.403636 | 0.816323 | 0.240235 |
| PONMF-S1 | MF | 0.18 | | 0.0003 | 0.2 | 0.382340 | 0.843148 | 0.403069 | 0.816484 | 0.239896 |
| PONMF-S1 | MF | 0.18 | | 0.0004 | 0.2 | 0.383573 | 0.843479 | 0.403994 | **0.817264** | 0.240482 |
| PONMF-S1 | MF | 0.18 | | 0.0005 | 0.2 | 0.383580 | 0.843000 | 0.403 | 0.816313 | 0.240263 |
| PONMF-S1 | MF | 0.18 | | 0.0006 | 0.2 | 0.381805 | 0.842988 | 0.402360 | 0.816254 | 0.239814 |
| PONMF-S1 | MF | 0.18 | | 0.0007 | 0.2 | 0.381923 | 0.843864 | 0.402906 | 0.816315 | 0.240003 |
| PONMF-S1 | MF | 0.18 | | 0.0008 | 0.2 | 0.381426 | 0.842790 | 0.401960 | 0.816138 | 0.239149 |
| PONMF-S1 | CC | 10 | | 0.001 | 0.2 | 0.173492 | 0.741557 | 0.203791 | 0.719279 | 0.081577 |
| PONMF-S1 | CC | 1 | | 0.001 | 0.2 | 0.445776 | 0.841563 | 0.460428 | 0.860861 | 0.293413 |
| PONMF-S1 | CC | 0.1 | | 0.001 | 0.2 | 0.484934 | 0.863551 | 0.502989 | 0.871649 | 0.328606 |
| PONMF-S1 | CC | 0.01 | | 0.001 | 0.2 | 0.489157 | 0.866894 | 0.506999 | 0.866234 | 0.331428 |
| PONMF-S1 | CC | 0.001 | | 0.001 | 0.2 | **0.489780** | **0.867533** | **0.507306** | 0.860989 | **0.331479** |
| PONMF-S1 | CC | 0.19 | | 0.0004 | 0.2 | 0.482247 | 0.863229 | 0.500344 | **0.872201** | 0.326690 |
| PONMF-S1 | CC | 0.18 | | 0.0002 | 0.2 | 0.382999 | 0.843092 | 0.403636 | 0.816323 | 0.240235 |
| PONMF-S1 | CC | 0.18 | | 0.0003 | 0.2 | 0.382340 | 0.843148 | 0.403069 | 0.816484 | 0.239896 |
| PONMF-S1 | CC | 0.18 | | 0.0004 | 0.2 | 0.383573 | 0.843479 | 0.403994 | 0.817264 | 0.240482 |
| PONMF-S1 | CC | 0.18 | | 0.0005 | 0.2 | 0.383580 | 0.843000 | 0.403453 | 0.816313 | 0.240263 |
| PONMF-S1 | CC | 0.18 | | 0.0006 | 0.2 | 0.381805 | 0.842988 | 0.402360 | 0.816254 | 0.239814 |
| PONMF-S1 | CC | 0.18 | | 0.0007 | 0.2 | 0.381923 | 0.843864 | 0.402906 | 0.816315 | 0.240003 |
| PONMF-S1 | CC | 0.18 | | 0.0008 | 0.2 | 0.381426 | 0.842790 | 0.401960 | 0.816138 | 0.239149 |
| PONMF-S1 | BP | 10 | | 0.001 | 0.5 | 0.249393 | 0.644371 | 0.233170 | 0.757171 | 0.119223 |
| PONMF-S1 | BP | 1 | | 0.001 | 0.5 | 0.369602 | 0.735564 | 0.365316 | 0.818759 | 0.244094 |
| PONMF-S1 | BP | 0.1 | | 0.001 | 0.5 | 0.387382 | 0.755728 | 0.385534 | 0.821465 | 0.260402 |
| PONMF-S1 | BP | 0.01 | | 0.001 | 0.5 | 0.389958 | 0.761651 | **0.388489** | 0.817701 | 0.262945 |
| PONMF-S1 | BP | 0.001 | | 0.001 | 0.5 | **0.390000** | **0.762769** | 0.388424 | 0.816047 | **0.263044** |
| PONMF-S1 | BP | 0.15 | | 0.0001 | 0.5 | 0.387008 | 0.753908 | 0.384915 | 0.821956 | 0.259777 |
| PONMF-S1 | BP | 0.15 | | 0.0002 | 0.5 | 0.387139 | 0.754904 | 0.385029 | **0.822223** | 0.259848 |
| PONMF-S1 | BP | 0.15 | | 0.0003 | 0.5 | 0.387261 | 0.755071 | 0.384979 | 0.822118 | 0.259894 |
| PONMF-S1 | BP | 0.15 | | 0.0004 | 0.5 | 0.386102 | 0.754952 | 0.384697 | 0.821787 | 0.259571 |
| PONMF-S1 | BP | 0.15 | | 0.0005 | 0.5 | 0.387103 | 0.754308 | 0.385183 | 0.821789 | 0.259945 |
| PONMF-S1 | BP | 0.15 | | 0.0006 | 0.5 | 0.386620 | 0.753857 | 0.384181 | 0.821762 | 0.259127 |
| PONMF-S1 | BP | 0.15 | | 0.0007 | 0.5 | 0.385997 | 0.753955 | 0.384204 | 0.821442 | 0.259342 |
| PONMF-S1 | BP | 0.15 | | 0.0008 | 0.5 | 0.386253 | 0.753918 | 0.384671 | 0.822220 | 0.259593 |

PONMF-S2 five-fold multi-column zeroing cross-validation on yeast dataset

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  |  | | , | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| PONMF-S2 | MF | 10 | | 0.001 | 0.2 | 0.320903 | 0.782001 | 0.325460 | 0.797257 | 0.179831 |
| PONMF-S2 | MF | 1 | | 0.001 | 0.2 | 0.381758 | 0.844057 | 0.403975 | 0.818954 | 0.241170 |
| PONMF-S2 | MF | 0.1 | | 0.001 | 0.2 | **0.394521** | 0.851677 | 0.415239 | 0.817950 | **0.247977** |
| PONMF-S2 | MF | 0.01 | | 0.001 | 0.2 | 0.391114 | **0.853941** | 0.412881 | 0.812131 | 0.245322 |
| PONMF-S2 | MF | 0.001 | | 0.01 | 0.2 | 0.386499 | 0.853795 | 0.408925 | 0.806238 | 0.242024 |
| PONMF-S2 | MF | 0.11 | | 0.001 | 0.2 | 0.393030 | 0.850798 | 0.414104 | 0.817304 | 0.247134 |
| PONMF-S2 | MF | 0.13 | | 0.001 | 0.2 | 0.394327 | 0.850795 | 0.414782 | 0.818068 | 0.247719 |
| PONMF-S2 | MF | 0.15 | | 0.001 | 0.2 | 0.392146 | 0.850654 | 0.412641 | 0.817415 | 0.246500 |
| PONMF-S2 | MF | 0.17 | | 0.001 | 0.2 | 0.390850 | 0.851230 | 0.412258 | 0.817362 | 0.245678 |
| PONMF-S2 | MF | 0.18 | | 0.001 | 0.2 | 0.392603 | 0.849614 | 0.413122 | 0.818157 | 0.246561 |
| PONMF-S2 | MF | 0.19 | | 0.001 | 0.2 | 0.393517 | 0.850711 | 0.414314 | 0.818644 | 0.247773 |
| PONMF-S2 | MF | 0.18 | | 0.0001 | 0.2 | 0.392165 | 0.851633 | 0.413489 | 0.817492 | 0.246801 |
| PONMF-S2 | MF | 0.18 | | 0.0002 | 0.2 | 0.392989 | 0.850656 | 0.413780 | 0.817694 | 0.246987 |
| PONMF-S2 | MF | 0.18 | | 0.0003 | 0.2 | 0.392670 | 0.849695 | 0.413411 | 0.817908 | 0.246729 |
| PONMF-S2 | MF | 0.18 | | 0.0004 | 0.2 | 0.394265 | 0.850374 | **0.414828** | **0.818763** | 0.247762 |
| PONMF-S2 | MF | 0.18 | | 0.0005 | 0.2 | 0.392720 | 0.850999 | 0.413543 | 0.817693 | 0.246843 |
| PONMF-S2 | MF | 0.18 | | 0.0006 | 0.2 | 0.391982 | 0.850968 | 0.412507 | 0.817715 | 0.246335 |
| PONMF-S2 | MF | 0.18 | | 0.0007 | 0.2 | 0.392482 | 0.851083 | 0.413015 | 0.817748 | 0.246637 |
| PONMF-S2 | MF | 0.18 | | 0.0008 | 0.2 | 0.390928 | 0.850474 | 0.412191 | 0.817489 | 0.245620 |
| PONMF-S2 | CC | 10 | | 0.001 | 0.2 | 0.443718 | 0.806060 | 0.447655 | 0.863047 | 0.273538 |
| PONMF-S2 | CC | 1 | | 0.001 | 0.2 | 0.481243 | 0.860471 | 0.500189 | 0.873773 | 0.323674 |
| PONMF-S2 | CC | 0.1 | | 0.001 | 0.2 | 0.499120 | 0.867026 | 0.517601 | 0.873826 | **0.336795** |
| PONMF-S2 | CC | 0.01 | | 0.001 | 0.2 | **0.499489** | **0.868956** | **0.517722** | 0.867482 | 0.335887 |
| PONMF-S2 | CC | 0.001 | | 0.001 | 0.2 | 0.496735 | 0.868717 | 0.515026 | 0.861632 | 0.332918 |
| PONMF-S2 | CC | 0.19 | | 0.0004 | 0.2 | 0.497945 | 0.867708 | 0.516640 | **0.874620** | 0.336242 |
| PONMF-S2 | CC | 0.18 | | 0.0002 | 0.2 | 0.392989 | 0.850656 | 0.413780 | 0.817694 | 0.246987 |
| PONMF-S2 | CC | 0.18 | | 0.0003 | 0.2 | 0.392670 | 0.849695 | 0.413411 | 0.817908 | 0.246729 |
| PONMF-S2 | CC | 0.18 | | 0.0004 | 0.2 | 0.394265 | 0.850374 | 0.414828 | 0.818763 | 0.247762 |
| PONMF-S2 | CC | 0.18 | | 0.0005 | 0.2 | 0.392720 | 0.850999 | 0.413543 | 0.817693 | 0.246843 |
| PONMF-S2 | CC | 0.18 | | 0.0006 | 0.2 | 0.391982 | 0.850968 | 0.412507 | 0.817715 | 0.246335 |
| PONMF-S2 | CC | 0.18 | | 0.0007 | 0.2 | 0.392482 | 0.851083 | 0.413015 | 0.817748 | 0.246637 |
| PONMF-S2 | CC | 0.18 | | 0.0008 | 0.2 | 0.390928 | 0.850474 | 0.412191 | 0.817489 | 0.245620 |
| PONMF-S2 | BP | 10 | | 0.001 | 0.5 | 0.352698 | 0.707390 | 0.344092 | 0.816357 | 0.219484 |
| PONMF-S2 | BP | 1 | | 0.001 | 0.5 | 0.393366 | 0.755855 | 0.390735 | **0.827328** | 0.265913 |
| PONMF-S2 | BP | 0.1 | | 0.001 | 0.5 | **0.403239** | 0.764631 | **0.399836** | 0.824328 | **0.272326** |
| PONMF-S2 | BP | 0.01 | | 0.001 | 0.5 | 0.401496 | 0.768087 | 0.398676 | 0.819632 | 0.270552 |
| PONMF-S2 | BP | 0.001 | | 0.001 | 0.5 | 0.397977 | 0.769832 | 0.396322 | 0.817517 | 0.268445 |
| PONMF-S2 | BP | 0.15 | | 0.0001 | 0.5 | 0.3666 | 0.7782 | 0.3738 | 0.8077 | 0.2542 |
| PONMF-S2 | BP | 0.15 | | 0.0002 | 0.5 | 0.3717 | 0.7824 | 0.377 | 0.8083 | 0.2566 |
| PONMF-S2 | BP | 0.15 | | 0.0003 | 0.5 | 0.3703 | 0.7827 | 0.3763 | 0.80845 | 0.25605 |
| PONMF-S2 | BP | 0.15 | | 0.0004 | 0.5 | 0.3689 | 0.7822 | 0.3755 | 0.8086 | 0.2556 |
| PONMF-S2 | BP | 0.15 | | 0.0005 | 0.5 | 0.3687 | 0.7822 | 0.3753 | 0.8085 | 0.2553 |
| PONMF-S2 | BP | 0.15 | | 0.0006 | 0.5 | 0.3683 | 0.7847 | 0.3757 | 0.8084 | 0.2552 |
| PONMF-S2 | BP | 0.15 | | 0.0007 | 0.5 | 0.3693 | 0.7876 | 0.3762 | 0.8085 | 0.2549 |
| PONMF-S2 | BP | 0.15 | | 0.0008 | 0.5 | 0.3685 | **0.7918** | 0.3763 | 0.8071 | 0.2524 |

PONMF-S1 five-fold multi-column zeroing cross-validation on huamn dataset

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  |  | | , | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| PONMF-S1 | MF | 10 | | 0.001 | 0.6 | 0.088446 | 0.765174 | 0.108896 | 0.714368 | 0.034167 |
| PONMF-S1 | MF | 1 | | 0.001 | 0.6 | 0.275327 | 0.778680 | 0.288781 | 0.834167 | 0.127550 |
| PONMF-S1 | MF | 0.1 | | 0.001 | 0.6 | 0.351528 | 0.799786 | 0.368123 | 0.887047 | 0.173992 |
| PONMF-S1 | MF | 0.01 | | 0.001 | 0.6 | 0.359795 | 0.8067975 | 0.378200 | 0.891347 | 0.179786 |
| PONMF-S1 | MF | 0.001 | | 0.01 | 0.6 | 0.356238 | **0.807729** | 0.375766 | 0.889554 | 0.178433 |
| PONMF-S1 | MF | 0.01 | | 0.0001 | 0.5 | 0.360379 | 0.807715 | 0.379334 | 0.891548 | 0.180584 |
| PONMF-S1 | MF | 0.02 | | 0.0001 | 0.5 | 0.362192 | 0.806383 | 0.380330 | 0.892181 | 0.181194 |
| PONMF-S1 | MF | 0.03 | | 0.0001 | 0.5 | 0.362815 | 0.806407 | **0.380884** | 0.892225 | **0.181415** |
| PONMF-S1 | MF | 0.04 | | 0.0001 | 0.5 | **0.362854** | 0.805602 | 0.380775 | **0.892520** | 0.181273 |
| PONMF-S1 | MF | 0.05 | | 0.0001 | 0.5 | 0.361803 | 0.805352 | 0.379555 | 0.892179 | 0.180679 |
| PONMF-S1 | MF | 0.06 | | 0.0001 | 0.5 | 0.356849 | 0.803129 | 0.374809 | 0.890436 | 0.177676 |
| PONMF-S1 | MF | 0.07 | | 0.0001 | 0.5 | 0.355912 | 0.802476 | 0.373601 | 0.889781 | 0.176909 |
| PONMF-S1 | MF | 0.08 | | 0.0001 | 0.5 | 0.355585 | 0.802229 | 0.372888 | 0.888994 | 0.176580 |
| PONMF-S1 | CC | 10 | | 0.001 | 0.4 | 0.101172 | 0.787737 | 0.130119 | 0.713877 | 0.043353 |
| PONMF-S1 | CC | 1 | | 0.001 | 0.4 | 0.222439 | 0.788207 | 0.244390 | 0.828754 | 0.097064 |
| PONMF-S1 | CC | 0.1 | | 0.001 | 0.4 | 0.385556 | 0.819945 | 0.402870 | 0.899005 | 0.193945 |
| PONMF-S1 | CC | 0.01 | | 0.001 | 0.4 | 0.407924 | **0.826321** | 0.425352 | 0.901352 | 0.208775 |
| PONMF-S1 | CC | 0.001 | | 0.001 | 0.4 | **0.408009** | 0.825451 | **0.425381** | 0.898626 | **0.209016** |
| PONMF-S1 | CC | 0.01 | | 0.001 | 0.4 | 0.407835 | 0.825695 | 0.425082 | 0.901104 | 0.208689 |
| PONMF-S1 | CC | 0.02 | | 0.001 | 0.4 | 0.407199 | 0.826042 | 0.424459 | 0.902137 | 0.208410 |
| PONMF-S1 | CC | 0.03 | | 0.001 | 0.4 | 0.406158 | 0.825801 | 0.423826 | **0.902932** | 0.207721 |
| PONMF-S1 | CC | 0.04 | | 0.001 | 0.4 | 0.402303 | 0.824843 | 0.419833 | 0.902397 | 0.205403 |
| PONMF-S1 | CC | 0.05 | | 0.001 | 0.4 | 0.397674 | 0.823857 | 0.415575 | 0.901178 | 0.202483 |
| PONMF-S1 | CC | 0.06 | | 0.001 | 0.4 | 0.394339 | 0.822348 | 0.412026 | 0.901223 | 0.200025 |
| PONMF-S1 | CC | 0.07 | | 0.001 | 0.4 | 0.391214 | 0.821648 | 0.409056 | 0.900769 | 0.197803 |
| PONMF-S1 | CC | 0.08 | | 0.001 | 0.4 | 0.389555 | 0.821275 | 0.407408 | 0.900595 | 0.196935 |
| PONMF-S1 | BP | 10 | | 0.001 | 0.3 | 0.061778 | 0.545062 | 0.067770 | 0.725837 | 0.020739 |
| PONMF-S1 | BP | 1 | | 0.001 | 0.3 | 0.268596 | 0.589526 | 0.251725 | 0.839778 | 0.137390 |
| PONMF-S1 | BP | 0.1 | | 0.001 | 0.3 | 0.392007 | 0.637777 | 0.364305 | 0.885300 | 0.229532 |
| PONMF-S1 | BP | 0.01 | | 0.001 | 0.3 | 0.408153 | 0.644976 | 0.379115 | 0.891743 | 0.241651 |
| PONMF-S1 | BP | 0.001 | | 0.001 | 0.3 | 0.409529 | 0.645328 | 0.380573 | 0.892459 | 0.242754 |
| PONMF-S1 | BP | 0.0001 | | 0.0001 | 0.3 | 0.410369 | **0.646334** | **0.381584** | **0.892839** | **0.243432** |
| PONMF-S1 | BP | 0.0002 | | 0.0001 | 0.3 | **0.410413** | 0.645985 | 0.381525 | 0.892764 | 0.243404 |
| PONMF-S1 | BP | 0.0004 | | 0.0001 | 0.3 | 0.410387 | 0.645916 | 0.381195 | 0.892673 | 0.243094 |
| PONMF-S1 | BP | 0.0005 | | 0.0001 | 0.3 | 0.409868 | 0.646088 | 0.380953 | 0.892632 | 0.242843 |
| PONMF-S1 | BP | 0.0006 | | 0.0001 | 0.3 | 0.409551 | 0.645799 | 0.380820 | 0.892644 | 0.242719 |
| PONMF-S1 | BP | 0.0007 | | 0.0001 | 0.3 | 0.409929 | 0.645674 | 0.381020 | 0.892594 | 0.242878 |
| PONMF-S1 | BP | 0.0008 | | 0.0001 | 0.3 | 0.409561 | 0.646020 | 0.380717 | 0.892527 | 0.242706 |

PONMF-S2 five-fold multi-column zeroing cross-validation on human dataset

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  |  | | , | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| PONMF-S2 | MF | 10 | | 0.001 | 0.6 | 0.382767 | 0.784810 | 0.379580 | 0.869838 | 0.181166 |
| PONMF-S2 | MF | 1 | | 0.001 | 0.6 | 0.377800 | 0.798019 | 0.391594 | 0.894077 | 0.187237 |
| PONMF-S2 | MF | 0.1 | | 0.001 | 0.6 | 0.407570 | 0.810947 | 0.422964 | 0.906794 | 0.206855 |
| PONMF-S2 | MF | 0.01 | | 0.001 | 0.6 | 0.419559 | 0.816884 | 0.435569 | 0.906914 | 0.215267 |
| PONMF-S2 | MF | 0.001 | | 0.01 | 0.6 | **0.424063** | **0.817932** | **0.440401** | 0.906394 | **0.218635** |
| PONMF-S2 | MF | 0.01 | | 0.0001 | 0.5 | 0.419232 | 0.816815 | 0.435619 | 0.906293 | 0.215249 |
| PONMF-S2 | MF | 0.02 | | 0.0001 | 0.5 | 0.417489 | 0.816035 | 0.433580 | 0.906694 | 0.213924 |
| PONMF-S2 | MF | 0.03 | | 0.0001 | 0.5 | 0.416433 | 0.815637 | 0.432495 | 0.906617 | 0.213099 |
| PONMF-S2 | MF | 0.04 | | 0.0001 | 0.5 | 0.416258 | 0.814992 | 0.431956 | 0.907004 | 0.212607 |
| PONMF-S2 | MF | 0.05 | | 0.0001 | 0.5 | 0.414842 | 0.814087 | 0.430575 | 0.906835 | 0.211619 |
| PONMF-S2 | MF | 0.06 | | 0.0001 | 0.5 | 0.411787 | 0.812387 | 0.427556 | **0.907163** | 0.209826 |
| PONMF-S2 | MF | 0.07 | | 0.0001 | 0.5 | 0.410958 | 0.812457 | 0.426456 | 0.907116 | 0.208926 |
| PONMF-S2 | MF | 0.08 | | 0.0001 | 0.5 | 0.410264 | 0.811999 | 0.425669 | 0.906822 | 0.208487 |
| PONMF-S2 | CC | 10 | | 0.001 | 0.4 | 0.426794 | 0.806585 | 0.425425 | 0.889017 | 0.207504 |
| PONMF-S2 | CC | 1 | | 0.001 | 0.4 | 0.402635 | 0.812482 | 0.415286 | 0.904604 | 0.197496 |
| PONMF-S2 | CC | 0.1 | | 0.001 | 0.4 | 0.438891 | 0.830751 | 0.453523 | **0.913780** | 0.226650 |
| PONMF-S2 | CC | 0.01 | | 0.001 | 0.4 | 0.452840 | **0.832617** | 0.465797 | 0.909718 | 0.235107 |
| PONMF-S2 | CC | 0.001 | | 0.001 | 0.4 | **0.455814** | 0.832036 | **0.468454** | 0.906672 | **0.236835** |
| PONMF-S2 | CC | 0.01 | | 0.001 | 0.4 | 0.453219 | 0.832003 | 0.465843 | 0.909495 | 0.235301 |
| PONMF-S2 | CC | 0.02 | | 0.001 | 0.4 | 0.450334 | 0.832388 | 0.463623 | 0.910949 | 0.233971 |
| PONMF-S2 | CC | 0.03 | | 0.001 | 0.4 | 0.449443 | 0.832220 | 0.463140 | 0.912155 | 0.233385 |
| PONMF-S2 | CC | 0.04 | | 0.001 | 0.4 | 0.448275 | 0.832091 | 0.462029 | 0.912635 | 0.232902 |
| PONMF-S2 | CC | 0.05 | | 0.001 | 0.4 | 0.444603 | 0.831522 | 0.458674 | 0.912439 | 0.230700 |
| PONMF-S2 | CC | 0.06 | | 0.001 | 0.4 | 0.444253 | 0.830833 | 0.458582 | 0.913353 | 0.230331 |
| PONMF-S2 | CC | 0.07 | | 0.001 | 0.4 | 0.442149 | 0.830715 | 0.456448 | 0.913551 | 0.228814 |
| PONMF-S2 | CC | 0.08 | | 0.001 | 0.4 | 0.441438 | 0.830707 | 0.456167 | 0.913765 | 0.228429 |
| PONMF-S2 | BP | 10 | | 0.001 | 0.3 | 0.496775 | 0.634333 | 0.437587 | 0.874006 | 0.283262 |
| PONMF-S2 | BP | 1 | | 0.001 | 0.3 | 0.441213 | 0.634058 | 0.397303 | 0.892614 | 0.250779 |
| PONMF-S2 | BP | 0.1 | | 0.001 | 0.3 | 0.477173 | 0.664953 | 0.441872 | 0.908609 | 0.288539 |
| PONMF-S2 | BP | 0.01 | | 0.001 | 0.3 | 0.498863 | 0.674098 | 0.460639 | 0.912174 | 0.304142 |
| PONMF-S2 | BP | 0.001 | | 0.001 | 0.3 | 0.509372 | 0.680558 | 0.470994 | 0.914008 | 0.312928 |
| PONMF-S2 | BP | 0.0001 | | 0.0001 | 0.3 | **0.511694** | 0.682796 | **0.473982** | **0.914343** | **0.315467** |
| PONMF-S2 | BP | 0.0002 | | 0.0001 | 0.3 | 0.511579 | **0.682446** | 0.473522 | 0.914315 | 0.315087 |
| PONMF-S2 | BP | 0.0004 | | 0.0001 | 0.3 | 0.511053 | 0.681844 | 0.472766 | 0.914139 | 0.314313 |
| PONMF-S2 | BP | 0.0005 | | 0.0001 | 0.3 | 0.510604 | 0.681359 | 0.472290 | 0.914089 | 0.313929 |
| PONMF-S2 | BP | 0.0006 | | 0.0001 | 0.3 | 0.510333 | 0.681241 | 0.472051 | 0.914072 | 0.313705 |
| PONMF-S2 | BP | 0.0007 | | 0.0001 | 0.3 | 0.510113 | 0.681187 | 0.471872 | 0.913928 | 0.313538 |
| PONMF-S2 | BP | 0.0008 | | 0.0001 | 0.3 | 0.510005 | **0.680861** | 0.471534 | 0.913854 | 0.313233 |

NMFGO five-fold multi-column zeroing cross-validation on yeast dataset

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| NMFGO | MF | 0.01 | 0.08725 | 0.822992 | 0.119557 | 0.543724 | 0.046348 |
| NMFGO | MF | 0.001 | 0.0929 | 0.8178 | 0.1212 | 0.5441 | 0.0472 |
| NMFGO | MF | 1 | 0.0925 | 0.803 | 0.1215 | 0.5669 | 0.0469 |
| NMFGO | MF | 3 | 0.0996 | 0.8138 | 0.1254 | 0.5592 | 0.0487 |
| NMFGO | MF | 5 | 0.102 | 0.8259 | 0.131 | 0.5528 | 0.0539 |
| NMFGO | MF | 7 | 0.1057 | 0.832 | 0.1313 | 0.5538 | 0.0543 |
| NMFGO | MF | 9 | 0.1065 | 0.8276 | 0.1308 | 0.5574 | 0.0552 |
| NMFGO | MF | 31 | 0.1195 | 0.8615 | 0.1392 | 0.5603 | 0.5603 |
| NMFGO | MF | 66 | 0.1211 | 0.8744 | 0.1415 | 0.57 | 0.0637 |
| NMFGO | MF | 91 | **0.1248** | **0.8837** | **0.145** | 0.5628 | 0.0672 |
| NMFGO | MF | 200 | 0.1188 | 0.875 | **0.145** | 0.5963 | **0.0679** |
| NMFGO | MF | 240 | 0.1149 | 0.8691 | 0.1417 | **0.6177** | 0.0656 |
| NMFGO | MF | 150 | 0.1153 | 0.8678 | 0.1421 | 0.614 | 0.0656 |
| NMFGO | CC | 0.001 | 0.0915 | 0.8098 | 0.1134 | 0.5311 | 0.0427 |
| NMFGO | CC | 0.01 | 0.103104 | 0.806202 | 0.11975 | 0.52757 | 0.0458 |
| NMFGO | CC | 1 | 0.1097 | **0.8706** | 0.1294 | 0.5272 | 0.0594 |
| NMFGO | CC | 9 | 0.1249 | 0.8251 | 0.1502 | 0.6216 | **0.078** |
| NMFGO | CC | 26 | 0.1398 | 0.762 | 0.1805 | 0.6902 | 0.0736 |
| NMFGO | CC | 51 | 0.1405 | 0.7799 | 0.1649 | **0.683** | 0.0694 |
| NMFGO | CC | 81 | 0.1425 | 0.7786 | 0.1653 | 0.6828 | 0.0702 |
| NMFGO | CC | 100 | **0.1426** | 0.7797 | **0.1654** | 0.6826 | 0.0702 |
| NMFGO | CC | 150 | 0.1424 | 0.7793 | **0.1654** | 0.6826 | 0.0702 |
| NMFGO | CC | 200 | 0.1424 | 0.7788 | **0.1654** | 0.6826 | 0.0702 |
| NMFGO | CC | 300 | 0.1425 | 0.7778 | **0.1654** | 0.6825 | 0.0702 |
| NMFGO | BP | 0.001 | 0.0756 | 0.7179 | 0.086 | 0.5432 | 0.0315 |
| NMFGO | BP | 0.01 | 0.072376 | 0.72219 | 0.084734 | 0.537965 | 0.030291 |
| NMFGO | BP | 1 | 0.0774 | 0.7124 | 0.0872 | 0.5445 | 0.0316 |
| NMFGO | BP | 11 | 0.0831 | 0.7139 | 0.0915 | 0.5571 | 0.0342 |
| NMFGO | BP | 36 | **0.0877** | 0.7433 | 0.0937 | 0.5533 | 0.0389 |
| NMFGO | BP | 50 | 0.0717 | 0.7503 | 0.0751 | 0.5028 | 0.0322 |
| NMFGO | BP | 81 | 0.0849 | 0.7619 | 0.0945 | 0.5479 | 0.0398 |
| NMFGO | BP | 100 | 0.0853 | 0.7654 | 0.0936 | 0.5482 | 0.0402 |
| NMFGO | BP | 120 | 0.0855 | 0.7597 | 0.0956 | 0.5492 | 0.0402 |
| NMFGO | BP | 130 | 0.0866 | 0.7648 | **0.0964** | **0.5597** | **0.0408** |
| NMFGO | BP | 140 | 0.0843 | 0.7765 | 0.0961 | 0.559 | 0.0398 |
| NMFGO | BP | 150 | 0.0835 | 0.7762 | 0.0956 | 0.5596 | 0.0406 |
| NMFGO | BP | 200 | 0.0834 | **0.777** | 0.0943 | 0.5567 | 0.0394 |

NMFGO two-fold multi-column zeroing cross-validation on human dataset

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| NMFGO | MF | 5 | 0.0829 | 0.775 | 0.1009 | 0.6662 | 0.0316 |
| NMFGO | MF | 10 | 0.0826 | 0.7704 | 0.1011 | 0.6811 | 0.0323 |
| NMFGO | MF | 15 | **0.0832** | 0.7688 | **0.1021** | 0.684 | **0.0324** |
| NMFGO | MF | 20 | 0.083 | 0.7686 | 0.102 | **0.6843** | 0.0323 |
| NMFGO | MF | 25 | 0.083 | 0.7686 | 0.102 | 0.6843 | 0.0323 |
| NMFGO | MF | 50 | 0.0815 | **0.7798** | 0.097 | 0.6706 | 0.0322 |
| NMFGO | MF | 100 | 0.0814 | 0.7793 | 0.0969 | 0.6704 | 0.0322 |
| NMFGO | CC | 0.06 | 0.044 | **0.8798** | 0.051 | 0.4429 | 0.0184 |
| NMFGO | CC | 0.6 | 0.0484 | 0.8283 | 0.0649 | 0.5646 | 0.0207 |
| NMFGO | CC | 5 | 0.0762 | 0.8051 | 0.1001 | 0.6541 | 0.0336 |
| NMFGO | CC | 10 | 0.0791 | 0.7966 | 0.1004 | 0.6584 | 0.0328 |
| NMFGO | CC | 20 | 0.0853 | 0.799 | 0.1083 | 0.676 | 0.0352 |
| NMFGO | CC | 40 | 0.0897 | 0.7912 | 0.1131 | 0.6911 | 0.0364 |
| NMFGO | CC | 50 | **0.0897** | 0.7914 | **0.1131** | **0.6915** | **0.0364** |
| NMFGO | CC | 75 | 0.0737 | 0.8023 | 0.0972 | 0.6796 | 0.0308 |
| NMFGO | CC | 100 | 0.0727 | 0.8042 | 0.0955 | 0.6782 | 0.0303 |
| NMFGO | BP | 0.005 | 0.0265 | 0.6519 | 0.0312 | 0.524 | 0.0118 |
| NMFGO | BP | 0.5 | 0.0321 | **0.6878** | 0.0433 | 0.5971 | 0.0178 |
| NMFGO | BP | 5 | 0.0426 | 0.648 | 0.0549 | 0.6453 | 0.0194 |
| NMFGO | BP | 10 | 0.0456 | 0.633 | 0.0555 | 0.6622 | **0.0219** |
| NMFGO | BP | 40 | 0.0482 | 0.593 | 0.0568 | 0.6738 | 0.0204 |
| NMFGO | BP | 50 | **0.0483** | 0.593 | **0.0569** | **0.6738** | 0.0204 |
| NMFGO | BP | 60 | 0.0418 | 0.6149 | 0.0519 | 0.6577 | 0.0185 |
| NMFGO | BP | 100 | 0.0418 | 0.6042 | 0.0516 | 0.6587 | 0.018 |
| NMFGO | BP | 150 | 0.0421 | 0.6036 | 0.0516 | 0.6584 | 0.0179 |

NMFGO five-fold randomly zeroing cross-validation on yeast dataset

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| NMFGO | MF | 0.001 | 0.418801 | 0.322753 | 0.292236 | 0.908748 | 0.210477 |
| NMFGO | MF | 0.01 | 0.421377 | 0.324048 | 0.296095 | 0.905954 | 0.212436 |
| NMFGO | MF | 1 | 0.322613 | **0.378262** | 0.296107 | 0.906304 | 0.217629 |
| NMFGO | MF | 5 | 0.772099 | 0.227858 | 0.351674 | 0.910989 | 0.280521 |
| NMFGO | MF | 11 | 0.789244 | 0.269246 | **0.401367** | 0.91214 | **0.320733** |
| NMFGO | MF | 51 | **0.80679** | 0.242521 | 0.372812 | 0.939154 | 0.294701 |
| NMFGO | MF | 66 | 0.770526 | 0.215677 | 0.336851 | **0.941181** | 0.261553 |
| NMFGO | MF | 71 | 0.781131 | 0.201133 | 0.319597 | 0.939816 | 0.244128 |
| NMFGO | MF | 100 | 0.771892 | 0.156649 | 0.260271 | 0.936101 | 0.191575 |
| NMFGO | CC | 0.001 | 0.732996 | **0.219031** | **0.335386** | 0.914205 | **0.247346** |
| NMFGO | CC | 0.01 | 0.751631 | 0.205948 | 0.322923 | 0.914381 | 0.238063 |
| NMFGO | CC | **0.09** | 0.749148 | 0.20547 | 0.322316 | 0.914815 | 0.236021 |
| NMFGO | CC | 1 | **0.794085** | 0.192027 | 0.308942 | **0.953863** | 0.218168 |
| NMFGO | CC | 3 | 0.74038 | 0.112655 | 0.195531 | 0.947912 | 0.123949 |
| NMFGO | CC | 9 | 0.015749 | 0.121498 | 0.027609 | 0.914023 | 0.008411 |
| NMFGO | CC | 51 | 0.004387 | 0.016701 | 0.006795 | **0.648091** | 0.00129 |
| NMFGO | CC | 100 | 0.004424 | 0.016677 | 0.006811 | 0.648497 | 0.001295 |
| NMFGO | BP | 0.001 | 0.58352 | 0.464231 | 0.516255 | 0.953904 | 0.466432 |
| NMFGO | BP | 0.01 | 0.614044 | 0.448065 | 0.517116 | 0.954414 | 0.465133 |
| NMFGO | BP | 1 | 0.630946 | 0.451038 | 0.525347 | 0.955693 | 0.477607 |
| NMFGO | BP | 11 | **0.639758** | **0.459788** | **0.533964** | 0.961615 | **0.494764** |
| NMFGO | BP | 46 | 0.608759 | 0.400824 | 0.483072 | 0.969396 | 0.453954 |
| NMFGO | BP | 51 | 0.586208 | 0.41529 | 0.484353 | **0.969969** | 0.453099 |
| NMFGO | BP | 56 | 0.582309 | 0.409507 | 0.479154 | 0.969385 | 0.448541 |
| NMFGO | BP | 100 | 0.569996 | 0.350599 | 0.431633 | 0.967926 | 0.391591 |

NMFGO two-fold randomly-column zeroing cross-validation on human dataset

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| methods | Process |  | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| NMFGO | MF | 0.02 | **0.0542** | 0.0455 | 0.0487 | 0.6532 | 0.0071 |
| NMFGO | MF | 0.1 | 0.0527 | 0.0489 | 0.0503 | 0.6997 | 0.008 |
| NMFGO | MF | 0.3 | 0.0304 | 0.1364 | 0.0495 | 0.7932 | 0.0089 |
| NMFGO | MF | 0.4 | 0.0343 | 0.1343 | **0.0546** | 0.8261 | **0.0098** |
| NMFGO | MF | 0.5 | 0.0338 | 0.1308 | 0.0537 | 0.8456 | 0.0091 |
| NMFGO | MF | 0.6 | 0.0307 | 0.1303 | 0.0496 | 0.8562 | 0.0081 |
| NMFGO | MF | 0.7 | 0.0292 | 0.1213 | 0.0469 | 0.8644 | 0.0077 |
| NMFGO | MF | 1 | 0.024 | 0.1039 | 0.039 | **0.8826** | 0.0064 |
| NMFGO | MF | 5 | 0.0067 | 0.1068 | 0.0117 | 0.8763 | 0.0032 |
| NMFGO | MF | 15 | 0.0046 | **0.231** | 0.009 | 0.8797 | 0.0025 |
| NMFGO | CC | 0.05 | 0.0281 | 0.0706 | 0.0358 | 0.6976 | 0.0054 |
| NMFGO | CC | 0.1 | **0.0329** | 0.0436 | 0.0352 | 0.6863 | 0.0049 |
| NMFGO | CC | 0.3 | 0.0227 | 0.1568 | 0.0396 | 0.7896 | 0.0078 |
| NMFGO | CC | 0.5 | 0.0238 | 0.1683 | 0.0416 | 0.8706 | 0.0094 |
| NMFGO | CC | 0.6 | 0.0244 | 0.1692 | **0.0427** | 0.8868 | **0.0096** |
| NMFGO | CC | 0.7 | 0.0221 | 0.1747 | 0.0392 | 0.8957 | 0.0091 |
| NMFGO | CC | 1 | 0.0179 | 0.1913 | 0.0327 | **0.9175** | 0.0086 |
| NMFGO | CC | 5 | 0.0063 | **0.3125** | 0.0123 | 0.9028 | 0.0039 |
| NMFGO | CC | 50 | 0.0031 | 0.2812 | 0.0061 | 0.8074 | 0.0017 |
| NMFGO | BP | 0.005 | 0.2412 | 0.2444 | 0.2424 | 0.9426 | 0.1341 |
| NMFGO | BP | 0.01 | 0.2544 | 0.2402 | 0.247 | 0.9436 | 0.1372 |
| NMFGO | BP | 0.03 | 0.2455 | 0.2467 | 0.2456 | 0.9427 | 0.1368 |
| NMFGO | BP | 0.04 | 0.2543 | 0.2399 | 0.2468 | 0.9439 | 0.1386 |
| NMFGO | BP | 0.05 | 0.2479 | 0.2552 | **0.2509** | 0.9436 | **0.1402** |
| NMFGO | BP | 0.06 | **0.2603** | 0.2396 | 0.2495 | 0.943 | 0.1355 |
| NMFGO | BP | 0.07 | 0.2509 | 0.2405 | 0.2455 | **0.9447** | 0.1349 |
| NMFGO | BP | 0.1 | 0.2579 | 0.2353 | 0.2458 | 0.9432 | 0.1373 |
| NMFGO | BP | 0.5 | 0.0401 | 0.1901 | 0.066 | 0.9396 | 0.0211 |
| NMFGO | BP | 1 | 0.0238 | 0.1648 | 0.041 | 0.9361 | 0.0127 |
| NMFGO | BP | 5 | 0.0093 | 0.3052 | 0.018 | 0.9198 | 0.0057 |
| NMFGO | BP | 50 | 0.0041 | **0.337** | 0.0081 | 0.8861 | 0.0026 |

Comparison of our methods

Five-fold randomly zeroing cross-validation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | species | Process | multiples | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| PONMF-S1 | Human | MF | 5-fold | **0.186363** | 0.132129 | **0.151553** | 0.955130 | **0.092670** |
| PONMF-S2 | Human | MF | 5-fold | 0.074034 | 0.152037 | 0.099242 | **0.973887** | 0.027436 |
| PONMF-S3 | Human | MF | 5-fold | 0.003663 | 0.507980 | 0.007273 | 0.935196 | 0.002032 |
| PONMF-S4 | Human | MF | 5-fold | 0.003925 | **0.587189** | 0.007799 | 0.961824 | 0.002433 |
| PONMF-S5 | Human | MF | 5-fold | 0.003716 | 0.582784 | 0.007385 | 0.964475 | 0.002359 |
| PONMF-S1 | Human | CC | 5-fold | **0.176323** | 0.127333 | **0.144467** | 0.955130 | **0.093686** |
| PONMF-S2 | Human | CC | 5-fold | 0.031884 | 0.111057 | 0.047556 | **0.973887** | 0.015177 |
| PONMF-S3 | Human | CC | 5-fold | 0.005306 | 0.458814 | 0.010490 | 0.935196 | 0.002839 |
| PONMF-S4 | Human | CC | 5-fold | 0.004597 | **0.514560** | 0.009112 | 0.961824 | 0.002929 |
| PONMF-S5 | Human | CC | 5-fold | 0.004120 | 0.523688 | 0.008176 | 0.964475 | 0.002698 |
| PONMF-S1 | Human | BP | 5-fold | **0.756378** | 0.396528 | **0.519880** | 0.971290 | **0.461531** |
| PONMF-S2 | Human | BP | 5-fold | 0.265116 | 0.341467 | 0.298161 | **0.985999** | 0.183969 |
| PONMF-S3 | Human | BP | 5-fold | 0.005142 | 0.710580 | 0.010210 | 0.943694 | 0.002773 |
| PONMF-S4 | Human | BP | 5-fold | 0.004900 | **0.714742** | 0.009733 | 0.967464 | 0.002905 |
| PONMF-S5 | Human | BP | 5-fold | 0.004579 | 0.698761 | 0.009098 | 0.967663 | 0.002779 |
| PONMF-S1 | Yeast | MF | 5-fold | **0.851982** | 0.605557 | **0.707454** | **0.983850** | **0.723884** |
| PONMF-S2 | Yeast | MF | 5-fold | 0.318174 | 0.503174 | 0.389660 | 0.978199 | 0.208562 |
| PONMF-S3 | Yeast | MF | 5-fold | 0.748203 | **0.608631** | 0.670859 | 0.971995 | 0.596324 |
| PONMF-S4 | Yeast | MF | 5-fold | 0.349133 | 0.539043 | 0.423624 | 0.974683 | 0.272515 |
| PONMF-S5 | Yeast | MF | 5-fold | 0.177445 | 0.517270 | 0.264117 | 0.974226 | 0.127511 |
| PONMF-S1 | Yeast | CC | 5-fold | **0.851568** | 0.568575 | **0.681447** | **0.983410** | **0.687748** |
| PONMF-S2 | Yeast | CC | 5-fold | 0.283996 | 0.502052 | 0.362565 | 0.979944 | 0.205663 |
| PONMF-S3 | Yeast | CC | 5-fold | 0.852615 | **0.568799** | 0.681942 | 0.972123 | 0.684901 |
| PONMF-S4 | Yeast | CC | 5-fold | 0.292654 | 0.506705 | 0.370807 | 0.975103 | 0.213138 |
| PONMF-S5 | Yeast | CC | 5-fold | 0.129427 | 0.512772 | 0.206556 | 0.975811 | 0.095124 |
| PONMF-S1 | Yeast | BP | 5-fold | **0.877765** | **0.652387** | **0.748223** | **0.988239** | **0.775486** |
| PONMF-S2 | Yeast | BP | 5-fold | 0.458773 | 0.573730 | 0.509558 | 0.984829 | 0.379914 |
| PONMF-S3 | Yeast | BP | 5-fold | 0.656108 | 0.642277 | 0.648925 | 0.981114 | 0.560287 |
| PONMF-S4 | Yeast | BP | 5-fold | 0.463453 | 0.587711 | 0.518011 | 0.982883 | 0.445392 |
| PONMF-S5 | Yeast | BP | 5-fold | 0.306556 | 0.501596 | 0.380284 | 0.981621 | 0.296845 |

five-fold multi-column zeroing cross-validation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| methods | species | Process | multiples | Precision | Recall | Fmeasure | avgAUC | avgAUP |
| PONMF-S1 | Human | MF | 5-fold | 0.362854 | 0.805602 | 0.380775 | 0.892520 | 0.181273 |
| PONMF-S2 | Human | MF | 5-fold | **0.416258** | **0.814992** | **0.431956** | 0.907004 | **0.212607** |
| PONMF-S3 | Human | MF | 5-fold | 0.411143 | 0.812179 | 0.426631 | **0.908309** | 0.208995 |
| PONMF-S4 | Human | MF | 5-fold | 0.404136 | 0.808445 | 0.418771 | 0.906532 | 0.203996 |
| PONMF-S5 | Human | MF | 5-fold | 0.397274 | 0.805509 | 0.411320 | 0.904020 | 0.199386 |
| PONMF-S1 | Human | CC | 5-fold | 0.406158 | 0.825801 | 0.423826 | 0.902932 | 0.207721 |
| PONMF-S2 | Human | CC | 5-fold | **0.449443** | **0.832220** | **0.463140** | 0.912155 | **0.233385** |
| PONMF-S3 | Human | CC | 5-fold | 0.446077 | 0.831311 | 0.459932 | **0.914940** | 0.231110 |
| PONMF-S4 | Human | CC | 5-fold | 0.439973 | 0.828916 | 0.453252 | 0.914825 | 0.226586 |
| PONMF-S5 | Human | CC | 5-fold | 0.434500 | 0.826101 | 0.446702 | 0.913600 | 0.222089 |
| PONMF-S1 | Human | BP | 5-fold | 0.410369 | 0.646334 | 0.381584 | 0.892839 | 0.243432 |
| PONMF-S2 | Human | BP | 5-fold | **0.511694** | **0.682796** | **0.473982** | 0.914343 | **0.315467** |
| PONMF-S3 | Human | BP | 5-fold | 0.499056 | 0.673467 | 0.461808 | **0.915242** | 0.304607 |
| PONMF-S4 | Human | BP | 5-fold | 0.488223 | 0.666110 | 0.451518 | 0.912212 | 0.295752 |
| PONMF-S5 | Human | BP | 5-fold | 0.479986 | 0.659627 | 0.443173 | 0.908746 | 0.288549 |
| PONMF-S1 | Yeast | MF | 5-fold | 0.383573 | 0.843479 | 0.403994 | 0.817264 | 0.240482 |
| PONMF-S2 | Yeast | MF | 5-fold | **0.394265** | **0.850374** | **0.414828** | 0.818763 | **0.247762** |
| PONMF-S3 | Yeast | MF | 5-fold | 0.387764 | 0.843454 | 0.408714 | 0.822635 | 0.242969 |
| PONMF-S4 | Yeast | MF | 5-fold | 0.378785 | 0.834934 | 0.399687 | **0.822949** | 0.236346 |
| PONMF-S5 | Yeast | MF | 5-fold | 0.372143 | 0.826074 | 0.391295 | 0.821685 | 0.229958 |
| PONMF-S1 | Yeast | CC | 5-fold | 0.482247 | 0.863229 | 0.500344 | 0.872201 | 0.326690 |
| PONMF-S2 | Yeast | CC | 5-fold | **0.497945** | **0.867708** | **0.516640** | 0.874620 | **0.336242** |
| PONMF-S3 | Yeast | CC | 5-fold | 0.491647 | 0.862115 | 0.510624 | 0.878764 | 0.330682 |
| PONMF-S4 | Yeast | CC | 5-fold | 0.483896 | 0.855646 | 0.502725 | **0.879639** | 0.323681 |
| PONMF-S5 | Yeast | CC | 5-fold | 0.477155 | 0.849394 | 0.495136 | 0.878975 | 0.317119 |
| PONMF-S1 | Yeast | BP | 5-fold | 0.387139 | 0.754904 | 0.385029 | 0.822223 | 0.259848 |
| PONMF-S2 | Yeast | BP | 5-fold | **0.402606** | **0.765045** | **0.399470** | 0.825290 | **0.272205** |
| PONMF-S3 | Yeast | BP | 5-fold | 0.397344 | 0.753972 | 0.393455 | **0.827997** | 0.266596 |
| PONMF-S4 | Yeast | BP | 5-fold | 0.390898 | 0.743638 | 0.386192 | 0.827754 | 0.260031 |
| PONMF-S5 | Yeast | BP | 5-fold | 0.384962 | 0.734082 | 0.379106 | 0.826200 | 0.253484 |