

Wstęp do Algorytmów Ewolucyjnych

Raport z testów

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1 Przypomnienie

Celem naszego projektu było zaimplementowanie zmodyfikowanego algorytmu ewolucji różnicowej, w którym jako pierwszy z 3 punktów stosowanych podczas mutacji wybierana była średnia punktów populacji a następnie porównanie tego rozwiązania z klasycznym algorytmem ewolucji różnicowej wykorzystując benchmark "cec2013" do testowania.

2 Lista zmian

W związku z długim czasem wykonywania się testów zmuszeni byliśmy przyjąć kilka poprawek w stosunku do przyjętych założeń ze Specyfikacji Wstępnej:

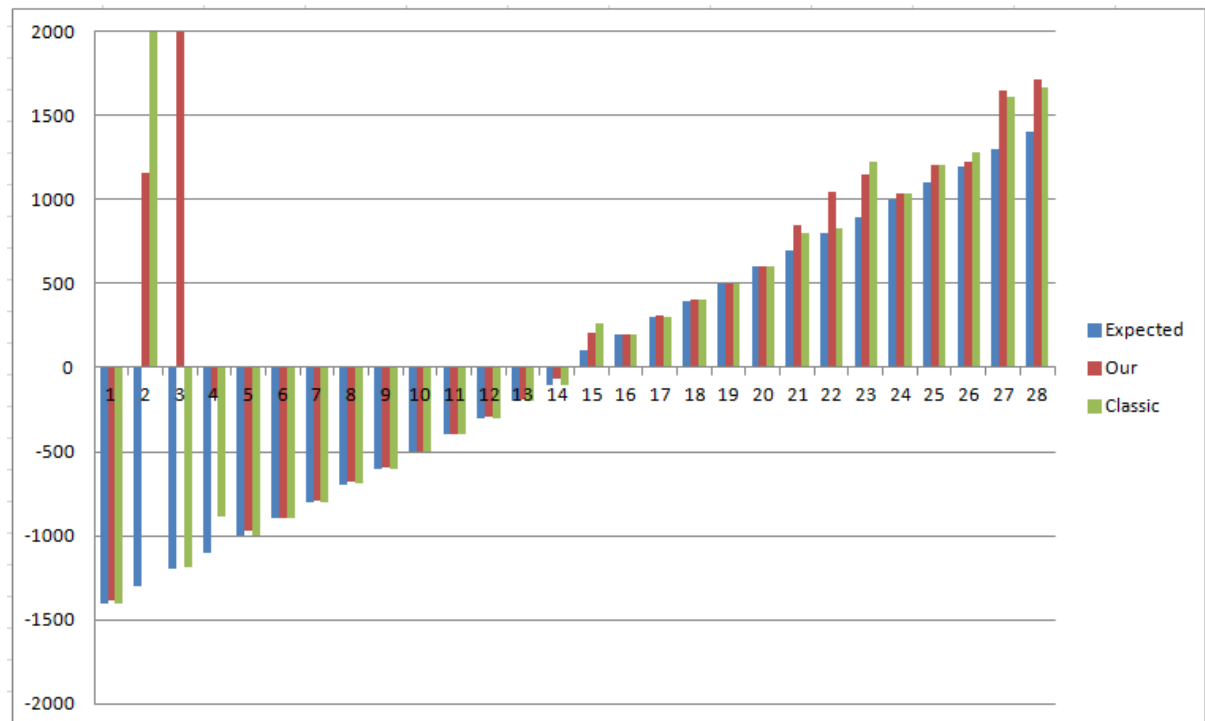
- Rozmiar wektorów dla których przeprowadziliśmy testy: 5 oraz 10
- Mniejsza liczba kombinacji współczynników F i Cr (patrz 3)
- Liczba iteracji dla każdego testu: 10
- Algorytm porównujemy wyłącznie z klasycznym algorytmem z losowym doбором 3 punktów w przeciwieństwie do wcześniejszego założenia o porównaniu go z algorytmem losowym i algorytmem, w którym jako pierwszy z trzech punktów wybierany jest najlepszy spośród obecnej populacji
- W warunku stopu dla algorytmów brana była pod uwagę liczba wywołań funkcji ewaluacyjnej zamiast - jak wcześniej założono - liczby iteracji.

3 Testy

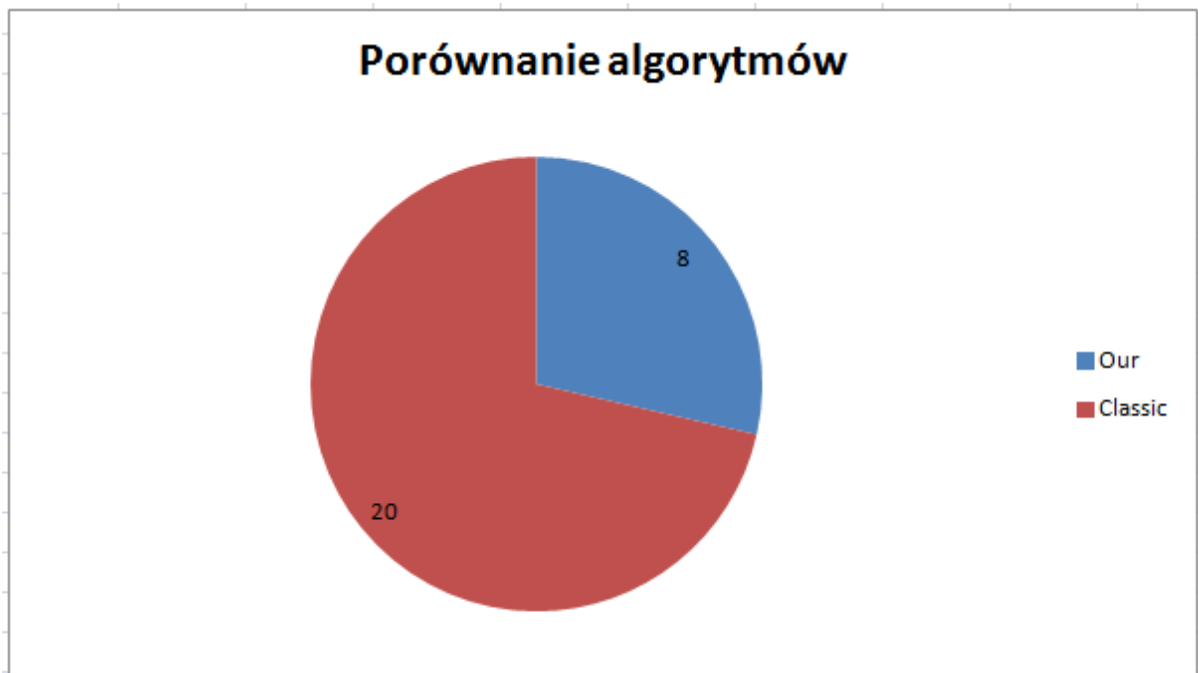
Zgodnie z wymaganiami, nasze testy przeprowadziliśmy na benchmarku "cec2013" dla naszego algorytmu oraz dla algorytmu klasycznego. Wyniki przedstawione zostały w tabelach poniżej.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1384,18 | -1400 | -1333,31 | -1400 | -1384,18 | -1400 | -1370,25 | -1400 | -1367,35 | -1400 | 15,01651 | 0 |
| 2 | -1300 | 1156,728 | 4641,86 | 30107,53 | 56645,84 | 1156,728 | 4641,86 | 13810,68 | 14740,68 | 14887,49 | 21565,07 | 9928,977 | 17062,73 |
| 3 | -1200 | 1805625 | -1190,81 | 30634901 | -1161,19 | 1805625 | -1190,81 | 10470177 | -1186,22 | 13080638 | -1183,4 | 10998504 | 8,724086 |
| 4 | -1100 | -179,027 | -887,022 | 4096,463 | 2511,969 | -179,027 | -887,022 | 1183,841 | 163,8953 | 1307,564 | 462,1636 | 1278,79 | 1090,967 |
| 5 | -1000 | -970,736 | -1000 | -925,914 | -1000 | -970,736 | -1000 | -953,681 | -1000 | -951,843 | -1000 | 16,20861 | 1,07E-12 |
| 6 | -900 | -899,904 | -899,693 | -893,609 | -898,24 | -899,904 | -899,693 | -899,384 | -899,194 | -898,435 | -899,125 | 1,955796 | 0,456921 |
| 7 | -800 | -794,186 | -799,953 | -785,075 | -799,895 | -794,186 | -799,953 | -790,403 | -799,939 | -789,952 | -799,932 | 2,857585 | 0,021419 |
| 8 | -700 | -679,977 | -684,684 | -679,889 | -679,908 | -679,977 | -684,684 | -679,92 | -681,66 | -679,925 | -682,022 | 0,02681 | 2,076632 |
| 9 | -600 | -597,886 | -598,79 | -597,355 | -597,935 | -597,886 | -598,79 | -597,672 | -598,501 | -597,657 | -598,433 | 0,200396 | 0,243134 |
| 10 | -500 | -496,878 | -499,891 | -482,504 | -499,687 | -496,878 | -499,891 | -492,861 | -499,762 | -491,765 | -499,782 | 4,61241 | 0,062525 |
| 11 | -400 | -396,778 | -400 | -385,093 | -400 | -396,778 | -400 | -392,298 | -400 | -391,709 | -400 | 3,486724 | 1,26E-09 |
| 12 | -300 | -292,83 | -297,54 | -288,88 | -293,938 | -292,83 | -297,54 | -291,621 | -295,78 | -291,546 | -295,881 | 1,20909 | 1,217766 |
| 13 | -200 | -192,943 | -197,309 | -184,228 | -194,153 | -192,943 | -197,309 | -187,264 | -196,421 | -187,856 | -196,154 | 3,026232 | 1,081974 |
| 14 | -100 | -67,1905 | -99,9354 | 51,84844 | -99,2744 | -67,1905 | -99,9354 | -6,45085 | -99,7962 | -3,86549 | -99,7353 | 36,2726 | 0,196819 |
| 15 | 100 | 210,3635 | 261,8744 | 446,379 | 432,3495 | 210,3635 | 261,8744 | 290,8801 | 324,2369 | 301,3162 | 329,6543 | 73,56902 | 59,75628 |
| 16 | 200 | 200,4707 | 200,5415 | 201,0253 | 201,2906 | 200,4707 | 200,5415 | 200,7723 | 200,8942 | 200,79 | 200,8927 | 0,164523 | 0,208745 |
| 17 | 300 | 306,7785 | 305,0946 | 312,0947 | 305,5326 | 306,7785 | 305,0946 | 309,435 | 305,2736 | 309,3859 | 305,2815 | 1,666895 | 0,131651 |
| 18 | 400 | 408,9578 | 407,8309 | 415,9946 | 411,1644 | 408,9578 | 407,8309 | 413,2098 | 409,0763 | 412,9012 | 409,4512 | 1,803454 | 1,351567 |
| 19 | 500 | 500,6359 | 500,0637 | 505,6257 | 500,2472 | 500,6359 | 500,0637 | 501,9458 | 500,1375 | 502,103 | 500,1551 | 1,442106 | 0,065075 |
| 20 | 600 | 600,3134 | 600,4136 | 601,0394 | 600,8734 | 600,3134 | 600,4136 | 600,6032 | 600,553 | 600,6735 | 600,6167 | 0,269639 | 0,18462 |
| 21 | 700 | 844,5157 | 801,8614 | 1030,745 | 960,6034 | 844,5157 | 801,8614 | 1022,933 | 812,7865 | 989,7526 | 844,0738 | 73,52123 | 56,32839 |
| 22 | 800 | 1044,989 | 829,7369 | 1278,041 | 972,8128 | 1044,989 | 829,7369 | 1200,268 | 937,0022 | 1179,939 | 930,2421 | 87,21754 | 38,80239 |
| 23 | 900 | 1151,529 | 1224,047 | 1509,545 | 1500,409 | 1151,529 | 1224,047 | 1390,36 | 1397,02 | 1357,299 | 1375,178 | 113,8177 | 92,97693 |
| 24 | 1000 | 1037,015 | 1040,008 | 1120,786 | 1123,718 | 1037,015 | 1040,008 | 1096,209 | 1115,369 | 1088,377 | 1107,657 | 26,41211 | 24,6928 |
| 25 | 1100 | 1207,837 | 1202,398 | 1238,829 | 1209,036 | 1207,837 | 1202,398 | 1227,038 | 1206,578 | 1226,784 | 1206,551 | 8,914443 | 2,022087 |
| 26 | 1200 | 1221,544 | 1285,927 | 1325,223 | 1305,021 | 1221,544 | 1285,927 | 1312,022 | 1304,631 | 1292,703 | 1300,052 | 48,28356 | 9,419986 |
| 27 | 1300 | 1645,227 | 1609,652 | 1672,212 | 1632,696 | 1645,227 | 1609,652 | 1656,876 | 1619,612 | 1658,176 | 1620,329 | 7,842577 | 8,234934 |
| 28 | 1400 | 1711,453 | 1666,266 | 1720,882 | 1700 | 1711,453 | 1666,266 | 1714,859 | 1700 | 1715,513 | 1691,567 | 4,512685 | 16,8673 |

Rysunek 1: 5-wymiarowa populacja. Wyniki dla parametrów: $F = 0.25$, $Cr = 0.25$



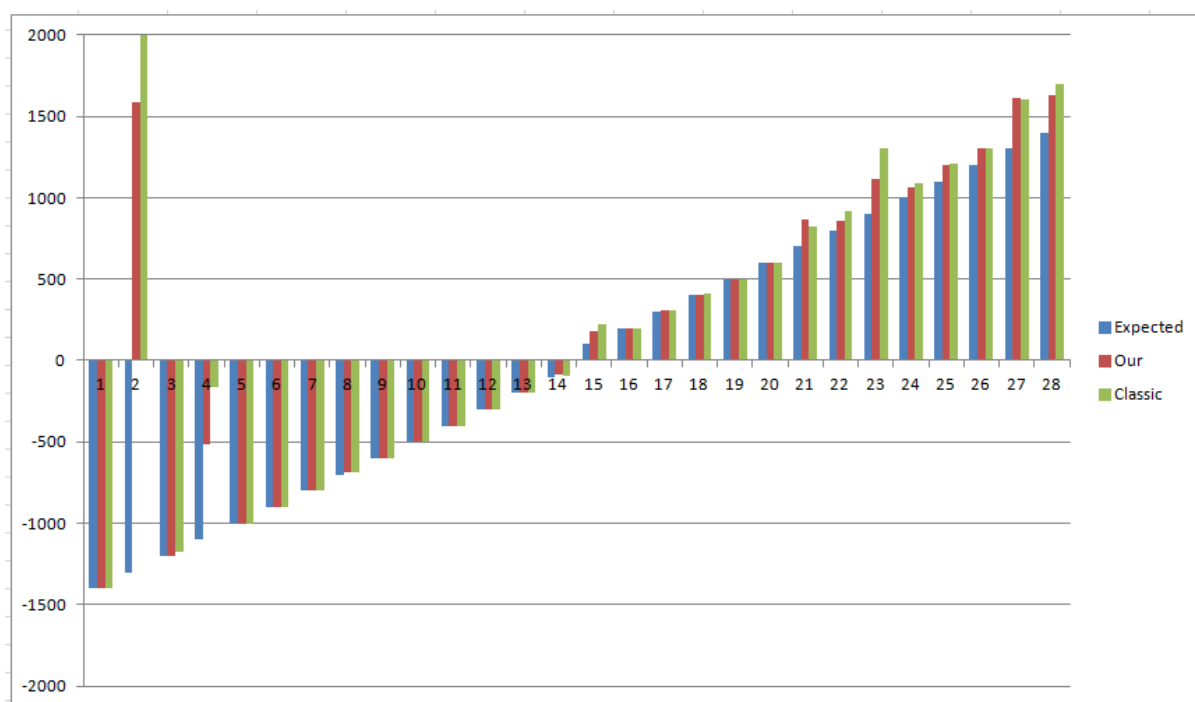
Rysunek 2: 5-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.25$, $Cr = 0.25$



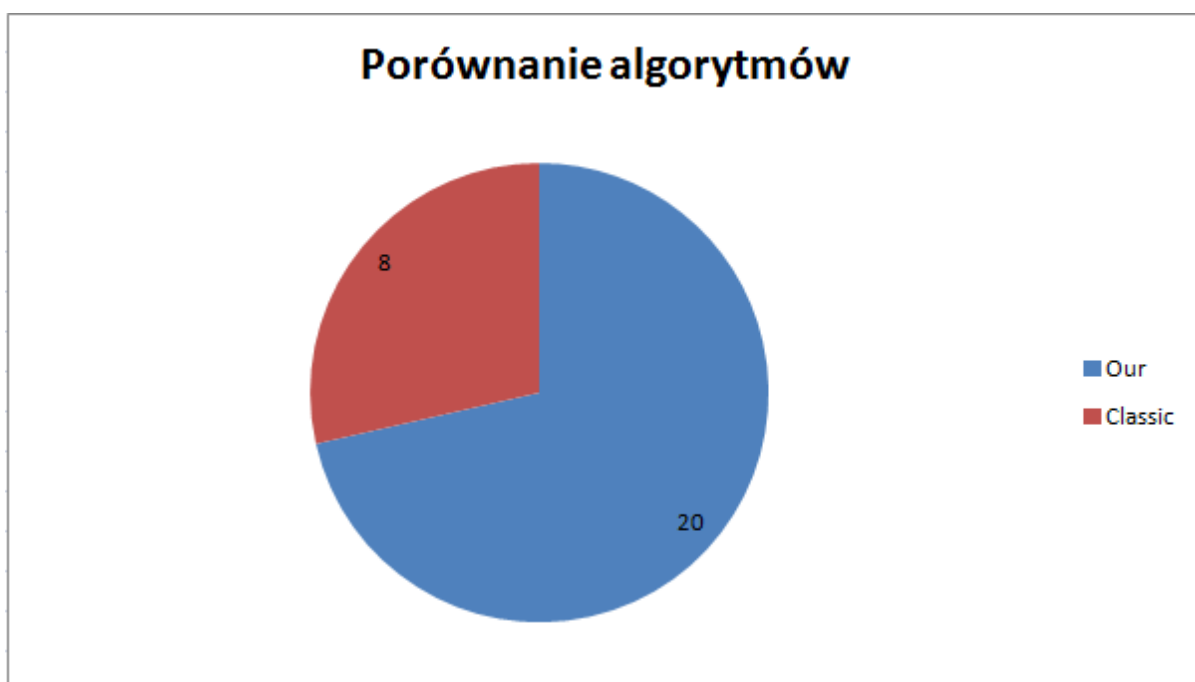
Rysunek 3: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | 2,14E-13 | 1,63E-11 |
| 2 | -1300 | 1588,435 | 18950,02 | 11561,2 | 86180,02 | 1588,435 | 18950,02 | 4834,593 | 34112,63 | 5957,9 | 44753,49 | 3639,269 | 23380,64 |
| 3 | -1200 | -1197,64 | -1177,06 | 8579,192 | -1091,32 | -1197,64 | -1177,06 | -833,569 | -1144,71 | 1089,477 | -1142,78 | 3955,759 | 29,4977 |
| 4 | -1100 | -513,23 | -165,438 | 234,2526 | 2809,427 | -513,23 | -165,438 | -227,623 | 883,4135 | -156,911 | 954,1101 | 285,072 | 924,5247 |
| 5 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | 4,4E-05 | 3,46E-09 |
| 6 | -900 | -900 | -899,696 | -899,931 | -898,434 | -900 | -899,696 | -899,977 | -898,986 | -899,972 | -898,975 | 0,023367 | 0,381019 |
| 7 | -800 | -799,769 | -799,803 | -794,397 | -799,287 | -799,769 | -799,803 | -799,008 | -799,573 | -798,523 | -799,561 | 1,666884 | 0,145909 |
| 8 | -700 | -686,007 | -685,446 | -679,881 | -679,911 | -686,007 | -685,446 | -683,54 | -680,327 | -683,461 | -681,286 | 2,001536 | 1,979801 |
| 9 | -600 | -599,065 | -598,433 | -597,967 | -597,866 | -599,065 | -598,433 | -598,412 | -598,037 | -598,425 | -598,078 | 0,311568 | 0,183084 |
| 10 | -500 | -499,807 | -499,806 | -498,154 | -499,413 | -499,807 | -499,806 | -499,331 | -499,574 | -499,234 | -499,584 | 0,482623 | 0,135821 |
| 11 | -400 | -399,954 | -400 | -397,811 | -400 | -399,954 | -400 | -399,559 | -400 | -399,275 | -400 | 0,721132 | 4,31E-06 |
| 12 | -300 | -297,84 | -296,804 | -296,197 | -290,377 | -297,84 | -296,804 | -297,313 | -294,544 | -297,149 | -294,267 | 0,536334 | 1,938666 |
| 13 | -200 | -196,644 | -196,615 | -193,772 | -190,656 | -196,644 | -196,615 | -194,629 | -194,662 | -194,948 | -194,59 | 0,980529 | 1,929896 |
| 14 | -100 | -85,9144 | -98,5011 | -29,174 | -91,0722 | -85,9144 | -98,5011 | -79,066 | -96,747 | -71,8439 | -96,3732 | 19,0171 | 2,075153 |
| 15 | 100 | 176,2218 | 220,7642 | 342,9022 | 493,7058 | 176,2218 | 220,7642 | 222,7768 | 348,3604 | 227,3364 | 355,0503 | 46,28518 | 101,4671 |
| 16 | 200 | 200,4419 | 200,6361 | 201,2797 | 201,2379 | 200,4419 | 200,6361 | 200,9413 | 200,9589 | 200,9378 | 200,9303 | 0,260089 | 0,19717 |
| 17 | 300 | 305,1286 | 305,0692 | 306,7551 | 305,1952 | 305,1286 | 305,0692 | 306,0143 | 305,0995 | 306,0015 | 305,1085 | 0,467775 | 0,039818 |
| 18 | 400 | 406,8389 | 408,1977 | 408,5966 | 412,8689 | 406,8389 | 408,1977 | 408,0266 | 409,943 | 407,8326 | 410,1152 | 0,639312 | 1,701436 |
| 19 | 500 | 500,025 | 500,0926 | 500,3582 | 500,2567 | 500,025 | 500,0926 | 500,1164 | 500,1842 | 500,1287 | 500,1822 | 0,095088 | 0,049058 |
| 20 | 600 | 600,3068 | 600,5311 | 600,5979 | 601,0122 | 600,3068 | 600,5311 | 600,4409 | 600,8883 | 600,4437 | 600,8065 | 0,09997 | 0,171601 |
| 21 | 700 | 862,6459 | 820,947 | 1014,52 | 1000,087 | 862,6459 | 820,947 | 979,4532 | 853,4012 | 961,0143 | 868,6285 | 53,22655 | 53,11894 |
| 22 | 800 | 861,8404 | 917,3707 | 1148,477 | 1043,88 | 861,8404 | 917,3707 | 970,6623 | 999,7371 | 972,27 | 995,8678 | 80,72027 | 36,72017 |
| 23 | 900 | 1115,615 | 1303,753 | 1473,192 | 1602,689 | 1115,615 | 1303,753 | 1230,152 | 1489,355 | 1246,501 | 1465,482 | 105,9872 | 117,2121 |
| 24 | 1000 | 1060,556 | 1085,258 | 1113,606 | 1130,682 | 1060,556 | 1085,258 | 1078,279 | 1124,533 | 1085,247 | 1119,958 | 23,68046 | 12,93618 |
| 25 | 1100 | 1202,885 | 1208,729 | 1209,214 | 1221,97 | 1202,885 | 1208,729 | 1206,653 | 1214,028 | 1206,21 | 1214,523 | 2,223992 | 4,299298 |
| 26 | 1200 | 1302,344 | 1300,327 | 1306,273 | 1307,206 | 1302,344 | 1300,327 | 1302,945 | 1305,429 | 1303,627 | 1304,598 | 1,792886 | 3,070708 |
| 27 | 1300 | 1608,93 | 1604,449 | 1626,197 | 1651,689 | 1608,93 | 1604,449 | 1618,119 | 1643,837 | 1617,61 | 1639,387 | 5,872554 | 14,23622 |
| 28 | 1400 | 1626,85 | 1700 | 1707,245 | 1700,018 | 1626,85 | 1700 | 1700,488 | 1700,001 | 1683,768 | 1700,005 | 38,07865 | 0,008682 |

Rysunek 4: 5-wymiarowa populacja. Wyniki dla parametrów: $F = 0.5$, $Cr = 0.25$



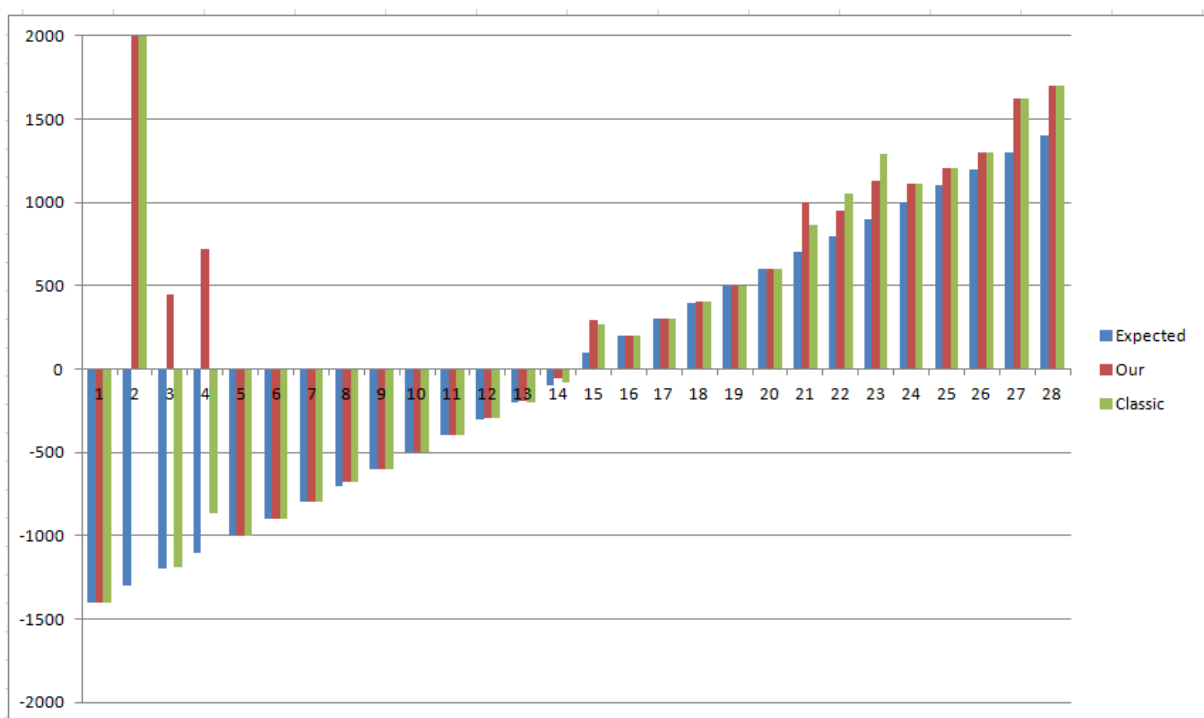
Rysunek 5: 5-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.5$, $Cr = 0.25$



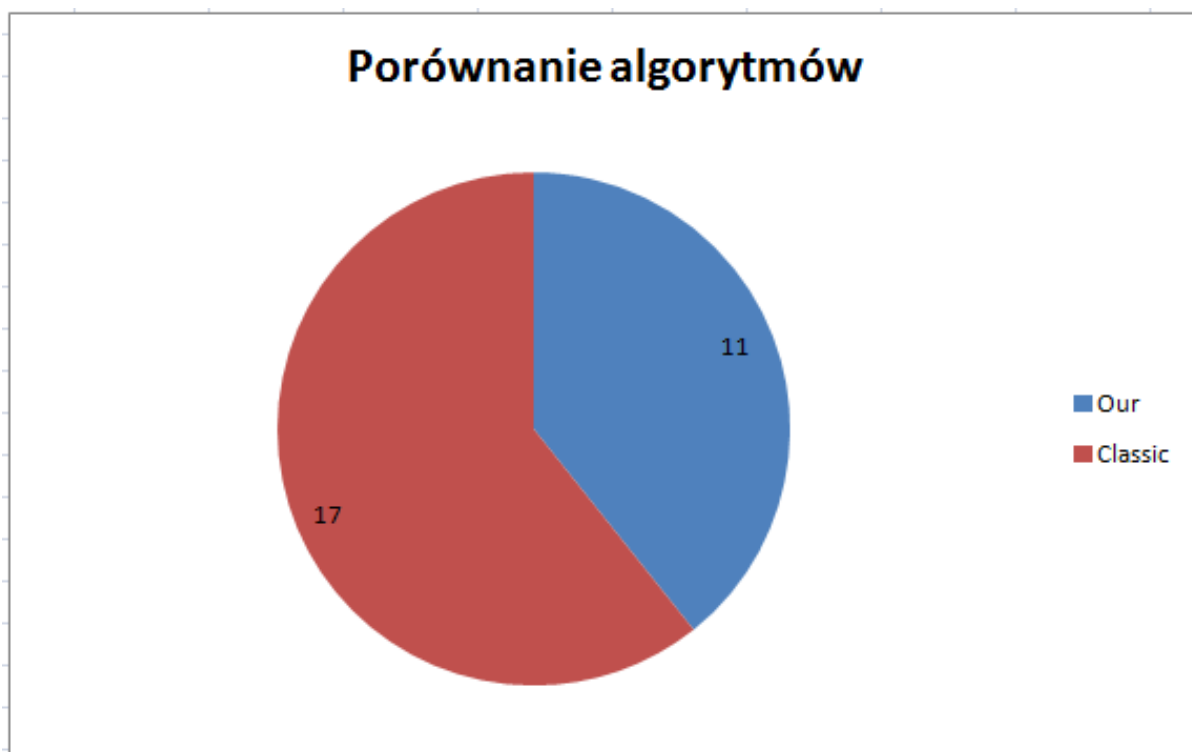
Rysunek 6: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1399,98 | -1400 | -1399,78 | -1400 | -1399,98 | -1400 | -1399,88 | -1400 | -1399,88 | -1400 | 0,14583 | 4,18E-12 |
| 2 | -1300 | 7428,328 | 7367,017 | 17557,65 | 10235,71 | 7428,328 | 7367,017 | 12492,99 | 8801,363 | 12492,99 | 8801,363 | 7162,511 | 2028,472 |
| 3 | -1200 | 450,0426 | -1191,93 | 55947,68 | -1169,44 | 450,0426 | -1191,93 | 28198,86 | -1180,68 | 28198,86 | -1180,68 | 39242,76 | 15,9017 |
| 4 | -1100 | 722,4114 | -866,878 | 912,4373 | -761,862 | 722,4114 | -866,878 | 817,4243 | -814,37 | 817,4243 | -814,37 | 134,3686 | 74,2573 |
| 5 | -1000 | -999,585 | -1000 | -997,784 | -1000 | -999,585 | -1000 | -998,685 | -1000 | -998,685 | -1000 | 1,273605 | 1,27E-09 |
| 6 | -900 | -899,928 | -899,587 | -899,906 | -899,444 | -899,928 | -899,587 | -899,917 | -899,516 | -899,917 | -899,516 | 0,015043 | 0,101248 |
| 7 | -800 | -797,176 | -799,961 | -795,059 | -799,942 | -797,176 | -799,961 | -796,117 | -799,952 | -796,117 | -799,952 | 1,496924 | 0,013601 |
| 8 | -700 | -679,918 | -681,346 | -679,904 | -679,906 | -679,918 | -681,346 | -679,911 | -680,626 | -679,911 | -680,626 | 0,009493 | 1,018249 |
| 9 | -600 | -598,001 | -598,253 | -597,799 | -597,932 | -598,001 | -598,253 | -597,9 | -598,092 | -597,9 | -598,092 | 0,142851 | 0,226614 |
| 10 | -500 | -499,381 | -499,807 | -496,57 | -499,793 | -499,381 | -499,807 | -497,975 | -499,8 | -497,975 | -499,8 | 1,987565 | 0,0103 |
| 11 | -400 | -398,98 | -399,904 | -397,936 | -399,895 | -398,98 | -399,904 | -398,458 | -399,9 | -398,458 | -399,9 | 0,738776 | 0,006026 |
| 12 | -300 | -297,655 | -295,138 | -296,627 | -294,966 | -297,655 | -295,138 | -297,141 | -295,052 | -297,141 | -295,052 | 0,727366 | 0,122108 |
| 13 | -200 | -193,732 | -197,332 | -192,81 | -194,151 | -193,732 | -197,332 | -193,271 | -195,741 | -193,271 | -195,741 | 0,652166 | 2,249903 |
| 14 | -100 | -54,6408 | -78,6143 | -52,1206 | -72,4392 | -54,6408 | -78,6143 | -53,3807 | -75,5268 | -53,3807 | -75,5268 | 1,78209 | 4,366478 |
| 15 | 100 | 294,2928 | 264,7415 | 309,8213 | 360,3045 | 294,2928 | 264,7415 | 302,0571 | 312,523 | 302,0571 | 312,523 | 10,98033 | 67,57321 |
| 16 | 200 | 201,0183 | 201,0594 | 201,12 | 201,1816 | 201,0183 | 201,0594 | 201,0691 | 201,1205 | 201,0691 | 201,1205 | 0,071903 | 0,086398 |
| 17 | 300 | 305,5726 | 305,6235 | 306,2736 | 305,86 | 305,5726 | 305,6235 | 305,9231 | 305,7417 | 305,9231 | 305,7417 | 0,495617 | 0,167205 |
| 18 | 400 | 408,8925 | 408,3276 | 409,1066 | 413,5725 | 408,8925 | 408,3276 | 408,9996 | 410,95 | 408,9996 | 410,95 | 0,151349 | 3,70871 |
| 19 | 500 | 500,2998 | 500,3499 | 500,3855 | 500,3547 | 500,2998 | 500,3499 | 500,3427 | 500,3523 | 500,3427 | 500,3523 | 0,060588 | 0,003432 |
| 20 | 600 | 600,4338 | 601,0813 | 600,6322 | 601,2034 | 600,4338 | 601,0813 | 600,533 | 601,1424 | 600,533 | 601,1424 | 0,140251 | 0,086365 |
| 21 | 700 | 1002,285 | 863,6733 | 1003,048 | 1000 | 1002,285 | 863,6733 | 1002,666 | 931,8368 | 1002,666 | 931,8368 | 0,539351 | 96,39765 |
| 22 | 800 | 946,6394 | 1053,48 | 991,7085 | 1147,238 | 946,6394 | 1053,48 | 969,174 | 1100,359 | 969,174 | 1100,359 | 31,86861 | 66,29706 |
| 23 | 900 | 1126,014 | 1293,098 | 1283,178 | 1336,155 | 1126,014 | 1293,098 | 1204,596 | 1314,626 | 1204,596 | 1314,626 | 111,1321 | 30,44607 |
| 24 | 1000 | 1108,336 | 1111,704 | 1126,041 | 1120,041 | 1108,336 | 1111,704 | 1117,188 | 1115,872 | 1117,188 | 1115,872 | 12,51936 | 5,894599 |
| 25 | 1100 | 1207,327 | 1209,436 | 1207,569 | 1210,549 | 1207,327 | 1209,436 | 1207,448 | 1209,993 | 1207,448 | 1209,993 | 0,170941 | 0,786856 |
| 26 | 1200 | 1303,64 | 1302,712 | 1303,991 | 1309,552 | 1303,64 | 1302,712 | 1303,815 | 1306,132 | 1303,815 | 1306,132 | 0,248222 | 4,836426 |
| 27 | 1300 | 1622,628 | 1626,738 | 1625,554 | 1636,468 | 1622,628 | 1626,738 | 1624,091 | 1631,603 | 1624,091 | 1631,603 | 2,068565 | 6,880332 |
| 28 | 1400 | 1700,334 | 1700 | 1700,985 | 1700 | 1700,334 | 1700 | 1700,66 | 1700 | 1700,66 | 1700 | 0,460081 | 8,34E-06 |

Rysunek 7: 5-wymiarowa populacja. Wyniki dla parametrów: $F = 0.5$, $Cr = 0.5$



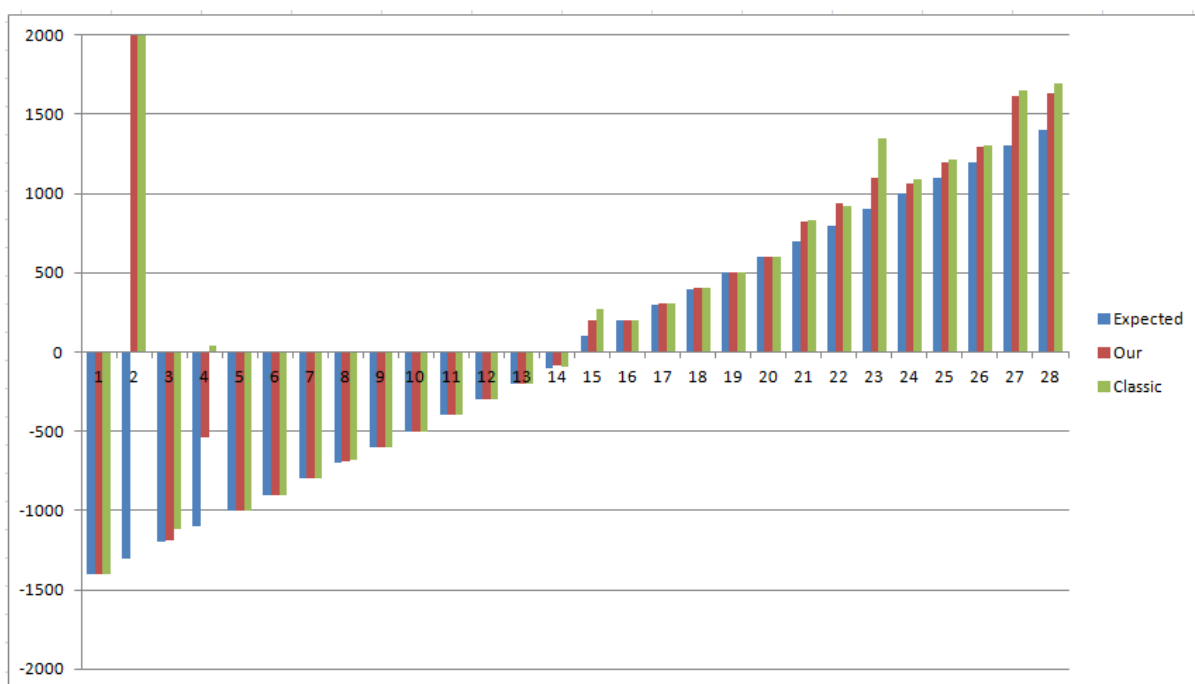
Rysunek 8: 5-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.5$, $Cr = 0.5$



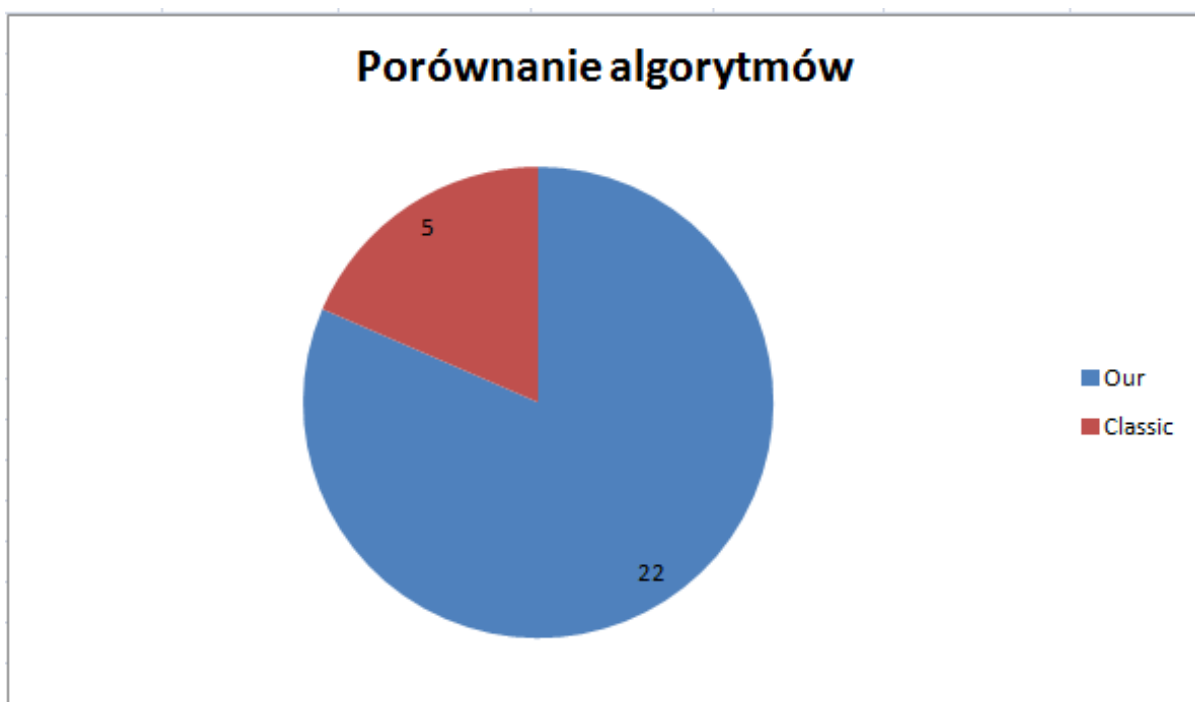
Rysunek 9: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|--------------|------------|--------------|------------|-------------|------------|--------------|-----------|-------------|------------|----------|----------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | 0 | 2,57E-08 |
| 2 | -1300 | 2641,205827 | 43632,7426 | 38731,69331 | 149504,491 | 2641,205827 | 43632,7426 | 20033,12356 | 74820,867 | 21996,02165 | 83056,681 | 12205,72 | 30116,92 |
| 3 | -1200 | -1189,359564 | -1114,5248 | 1239,639608 | 184,116562 | -1189,35956 | -1114,5248 | -1150,384848 | -805,2054 | -804,301798 | -672,66508 | 749,0751 | 398,4963 |
| 4 | -1100 | -538,2202457 | 39,2707742 | 282,5290922 | 3896,28533 | -628,353973 | 39,2707742 | -71,91528375 | 1715,5675 | -119,317093 | 1894,4261 | 314,6242 | 1351,143 |
| 5 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | 5,47E-12 | 7,35E-07 |
| 6 | -900 | -899,8526674 | -899,68691 | -898,2316222 | -897,9969 | -899,852667 | -899,68691 | -899,1364574 | -898,8485 | -899,099239 | -898,81086 | 0,563098 | 0,508973 |
| 7 | -800 | -799,9048873 | -798,61454 | -799,4168242 | -797,53177 | -799,904887 | -798,61454 | -799,6133927 | -798,2279 | -799,622857 | -798,14625 | 0,16613 | 0,40289 |
| 8 | -700 | -687,4251382 | -679,97364 | -679,8746751 | -679,81346 | -687,425138 | -679,97364 | -680,4433413 | -679,8885 | -681,356438 | -679,8961 | 2,317733 | 0,051659 |
| 9 | -600 | -598,4431876 | -598,34308 | -597,7151825 | -597,4586 | -598,443188 | -598,34308 | -598,1117156 | -597,9049 | -598,122281 | -597,88813 | 0,232293 | 0,257978 |
| 10 | -500 | -499,8260991 | -499,47324 | -499,645052 | -499,09109 | -499,826099 | -499,47324 | -499,7399741 | -499,2526 | -499,734516 | -499,27765 | 0,060626 | 0,125345 |
| 11 | -400 | -399,9152082 | -399,99939 | -397,8904688 | -399,98692 | -399,915208 | -399,99939 | -398,7577897 | -399,9964 | -398,764777 | -399,9954 | 0,544233 | 0,00427 |
| 12 | -300 | -298,7196054 | -296,28878 | -294,0812163 | -291,31959 | -298,719605 | -296,28878 | -296,0723905 | -292,9259 | -296,238584 | -293,20398 | 1,438901 | 1,41353 |
| 13 | -200 | -197,3068991 | -197,67327 | -194,0134055 | -190,48962 | -197,306899 | -197,67327 | -195,3131667 | -193,0764 | -195,438863 | -193,75407 | 1,264511 | 2,097517 |
| 14 | -100 | -80,69918688 | -97,899265 | -42,9841503 | -89,201003 | -80,6991869 | -97,899265 | -53,61233036 | -93,47985 | -56,5435824 | -93,745073 | 12,8137 | 2,61659 |
| 15 | 100 | 200,6742886 | 273,135575 | 516,6266546 | 643,558234 | 200,6742886 | 273,135575 | 353,3463836 | 447,33995 | 366,0872009 | 429,85794 | 96,34582 | 123,6529 |
| 16 | 200 | 200,4254656 | 200,771073 | 201,068015 | 201,336382 | 200,4254656 | 200,771073 | 200,7979701 | 201,00966 | 200,7848449 | 201,03952 | 0,211387 | 0,225259 |
| 17 | 300 | 305,6288381 | 305,782732 | 306,3075529 | 306,881326 | 305,6288381 | 305,782732 | 305,8842818 | 306,39376 | 305,9467306 | 306,39941 | 0,224849 | 0,31072 |
| 18 | 400 | 406,4622736 | 409,234551 | 412,1021421 | 415,940271 | 406,4622736 | 409,234551 | 409,0648287 | 411,88269 | 409,1180176 | 412,17231 | 1,378758 | 2,096871 |
| 19 | 500 | 500,0940972 | 500,096491 | 500,3003974 | 500,365141 | 500,0940972 | 500,096491 | 500,2355994 | 500,21744 | 500,2177346 | 500,23446 | 0,061476 | 0,081323 |
| 20 | 600 | 600,5878289 | 600,443101 | 600,9867115 | 601,196652 | 600,5878289 | 600,443101 | 600,8058348 | 600,88036 | 600,7898179 | 600,86222 | 0,136243 | 0,250092 |
| 21 | 700 | 824,2299421 | 833,428466 | 1002,595272 | 924,509468 | 824,2299421 | 833,428466 | 851,9038598 | 886,43861 | 869,8742862 | 884,4605 | 53,8011 | 27,59442 |
| 22 | 800 | 942,4361213 | 917,405253 | 1022,199334 | 1026,93611 | 942,4361213 | 917,405253 | 975,712639 | 990,921 | 975,651549 | 984,2058 | 24,62439 | 31,26805 |
| 23 | 900 | 1102,727978 | 1352,17068 | 1505,740351 | 1631,55418 | 1102,727978 | 1352,17068 | 1285,708545 | 1478,3716 | 1308,310288 | 1478,6555 | 131,4922 | 91,15193 |
| 24 | 1000 | 1063,603426 | 1094,06702 | 1124,4904 | 1135,56604 | 1063,603426 | 1094,06702 | 1119,181442 | 1122,4272 | 1107,254158 | 1121,0495 | 20,88839 | 11,67902 |
| 25 | 1100 | 1196,679912 | 1212,2566 | 1217,861083 | 1227,7736 | 1196,679912 | 1212,2566 | 1209,571499 | 1220,2677 | 1209,113315 | 1220,4551 | 5,270627 | 4,374888 |
| 26 | 1200 | 1298,814923 | 1306,44915 | 1310,390195 | 1316,09284 | 1298,814923 | 1306,44915 | 1307,250232 | 1312,2154 | 1305,926395 | 1311,7432 | 4,972896 | 3,992576 |
| 27 | 1300 | 1614,604136 | 1649,18204 | 1642,291815 | 1668,55012 | 1614,604136 | 1649,18204 | 1625,393503 | 1658,3325 | 1625,712579 | 1659,0699 | 7,710709 | 5,352687 |
| 28 | 1400 | 1635,118293 | 1696,92592 | 1711,428359 | 1700,41934 | 1635,118293 | 1696,92592 | 1688,636187 | 1700,0684 | 1680,954756 | 1699,3705 | 35,02171 | 1,638168 |

Rysunek 10: 5-wymiarowa populacja. Wyniki dla parametrów: $F = 0.75$, $Cr = 0.25$



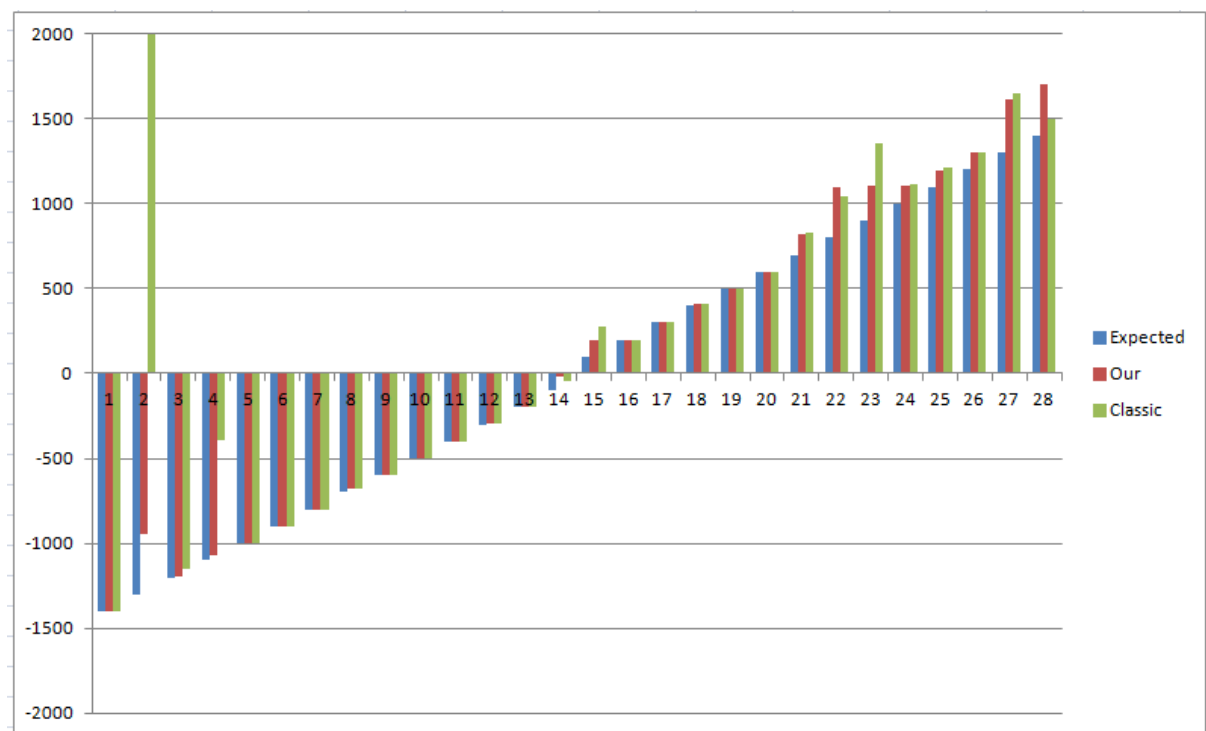
Rysunek 11: 5-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.75$, $Cr = 0.25$



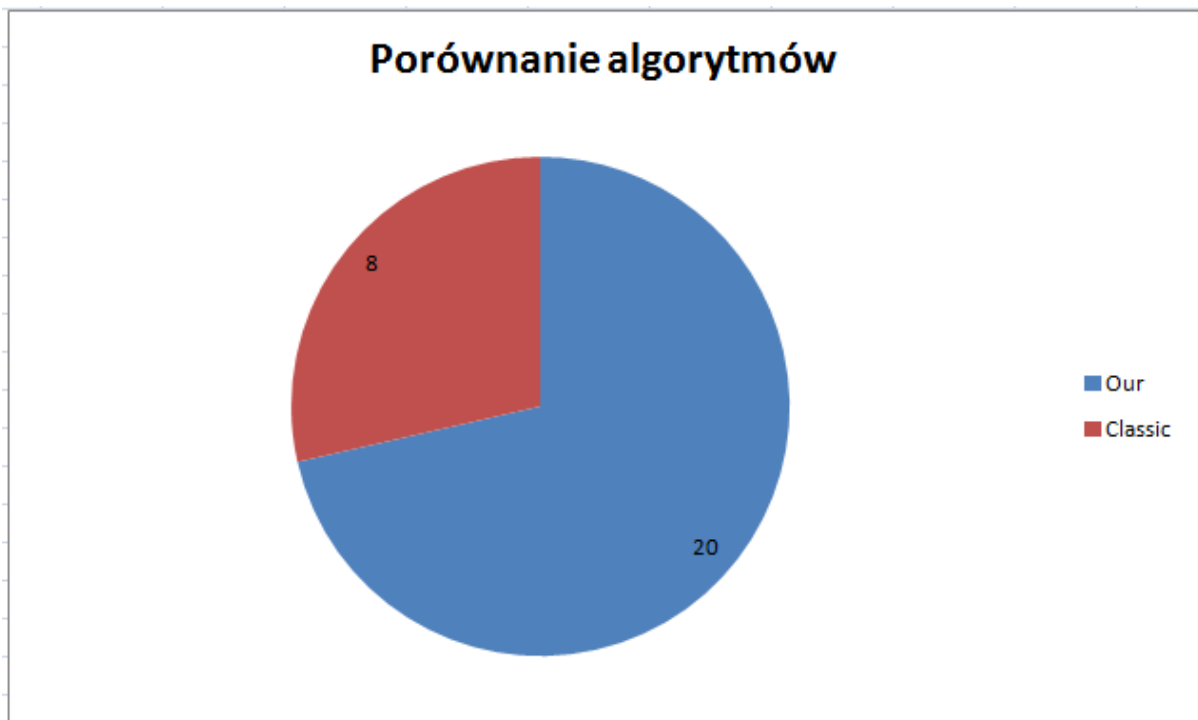
Rysunek 12: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | 0 | 1,09E-07 |
| 2 | -1300 | -948,537 | 14361,29 | 1103,97 | 76960,81 | -948,537 | 14361,29 | 421,4619 | 35400,56 | 236,2005 | 35308,54 | 735,3569 | 19080,86 |
| 3 | -1200 | -1197,45 | -1146,35 | -1193,02 | -730,753 | -1197,45 | -1146,35 | -1193,8 | -1022,55 | -1194,47 | -1013,96 | 1,52228 | 134,9131 |
| 4 | -1100 | -1069,04 | -389,788 | -950,542 | 936,5605 | -1069,04 | -389,788 | -1022,89 | 442,6823 | -1018,34 | 344,2446 | 37,35708 | 416,5603 |
| 5 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | 1,37E-13 | 3,64E-06 |
| 6 | -900 | -899,812 | -899,672 | -898,677 | -899,333 | -899,812 | -899,672 | -899,278 | -899,496 | -899,283 | -899,52 | 0,293529 | 0,115687 |
| 7 | -800 | -799,905 | -798,615 | -799,417 | -797,532 | -799,905 | -798,615 | -799,613 | -798,228 | -799,623 | -798,146 | 0,16613 | 0,40289 |
| 8 | -700 | -681,325 | -681,764 | -679,913 | -679,887 | -681,325 | -681,764 | -680,258 | -679,944 | -680,507 | -680,18 | 0,593663 | 0,596981 |
| 9 | -600 | -598,443 | -598,343 | -597,715 | -597,459 | -598,443 | -598,343 | -598,112 | -597,905 | -598,122 | -597,888 | 0,232293 | 0,257978 |
| 10 | -500 | -499,927 | -499,886 | -499,782 | -499,571 | -499,927 | -499,886 | -499,878 | -499,69 | -499,869 | -499,704 | 0,046456 | 0,101164 |
| 11 | -400 | -399,915 | -399,999 | -397,89 | -399,987 | -399,915 | -399,999 | -398,758 | -399,996 | -398,765 | -399,995 | 0,544233 | 0,00427 |
| 12 | -300 | -297,222 | -294,872 | -294,399 | -291,496 | -297,222 | -294,872 | -296,008 | -292,903 | -295,823 | -292,908 | 0,909424 | 1,171595 |
| 13 | -200 | -197,307 | -197,673 | -194,013 | -190,49 | -197,307 | -197,673 | -195,313 | -193,076 | -195,439 | -193,754 | 1,264511 | 2,097517 |
| 14 | -100 | -14,5728 | -44,0822 | 99,07942 | 29,34322 | -14,5728 | -44,0822 | 41,14872 | 3,734683 | 42,20246 | 0,984359 | 35,78269 | 27,04602 |
| 15 | 100 | 200,6743 | 273,1356 | 516,6267 | 643,5582 | 200,6743 | 273,1356 | 353,3464 | 447,3399 | 366,0872 | 429,8579 | 96,34582 | 123,6529 |
| 16 | 200 | 200,6101 | 200,544 | 201,2273 | 201,5633 | 200,6101 | 200,544 | 200,8808 | 200,9435 | 200,886 | 200,9821 | 0,233536 | 0,306667 |
| 17 | 300 | 305,6288 | 305,7827 | 306,3076 | 306,8813 | 305,6288 | 305,7827 | 305,8843 | 306,3938 | 305,9467 | 306,3994 | 0,224849 | 0,31072 |
| 18 | 400 | 407,8169 | 411,7178 | 411,1888 | 414,8282 | 407,8169 | 411,7178 | 409,055 | 413,8126 | 409,2492 | 413,5056 | 1,192571 | 1,034694 |
| 19 | 500 | 500,0941 | 500,0965 | 500,3004 | 500,3651 | 500,0941 | 500,0965 | 500,2356 | 500,2174 | 500,2177 | 500,2345 | 0,061476 | 0,081323 |
| 20 | 600 | 600,4777 | 600,4439 | 600,9725 | 601,1893 | 600,4777 | 600,4439 | 600,6017 | 601,0855 | 600,6502 | 600,9818 | 0,153551 | 0,226496 |
| 21 | 700 | 824,2299 | 833,4285 | 1002,595 | 924,5095 | 824,2299 | 833,4285 | 851,9039 | 886,4386 | 869,8743 | 884,4605 | 53,8011 | 27,59442 |
| 22 | 800 | 1095,012 | 1040,445 | 1307,034 | 1234,147 | 1095,012 | 1040,445 | 1213,495 | 1169,243 | 1203,22 | 1155,978 | 70,75198 | 59,50289 |
| 23 | 900 | 1102,728 | 1352,171 | 1505,74 | 1631,554 | 1102,728 | 1352,171 | 1285,709 | 1478,372 | 1308,31 | 1478,656 | 131,4922 | 91,15193 |
| 24 | 1000 | 1110,533 | 1111,098 | 1119,801 | 1122,194 | 1110,533 | 1111,098 | 1117,156 | 1117,847 | 1116,382 | 1117,475 | 3,022075 | 2,834872 |
| 25 | 1100 | 1196,68 | 1212,257 | 1217,861 | 1227,774 | 1196,68 | 1212,257 | 1209,571 | 1220,268 | 1209,113 | 1220,455 | 5,270627 | 4,374888 |
| 26 | 1200 | 1303,957 | 1304,25 | 1307,599 | 1311,692 | 1303,957 | 1304,25 | 1305,242 | 1307,8 | 1305,643 | 1307,585 | 1,301178 | 2,172317 |
| 27 | 1300 | 1614,604 | 1649,182 | 1642,292 | 1668,55 | 1614,604 | 1649,182 | 1625,394 | 1658,333 | 1625,713 | 1659,07 | 7,710709 | 5,352687 |
| 28 | 1400 | 1700 | 1500,211 | 1700 | 1700,012 | 1700 | 1500,211 | 1700 | 1700,006 | 1700 | 1660,05 | 5,43E-07 | 84,23767 |

Rysunek 13: 5-wymiarowa populacja. Wyniki dla parametrów: $F = 0.75$, $Cr = 0.5$



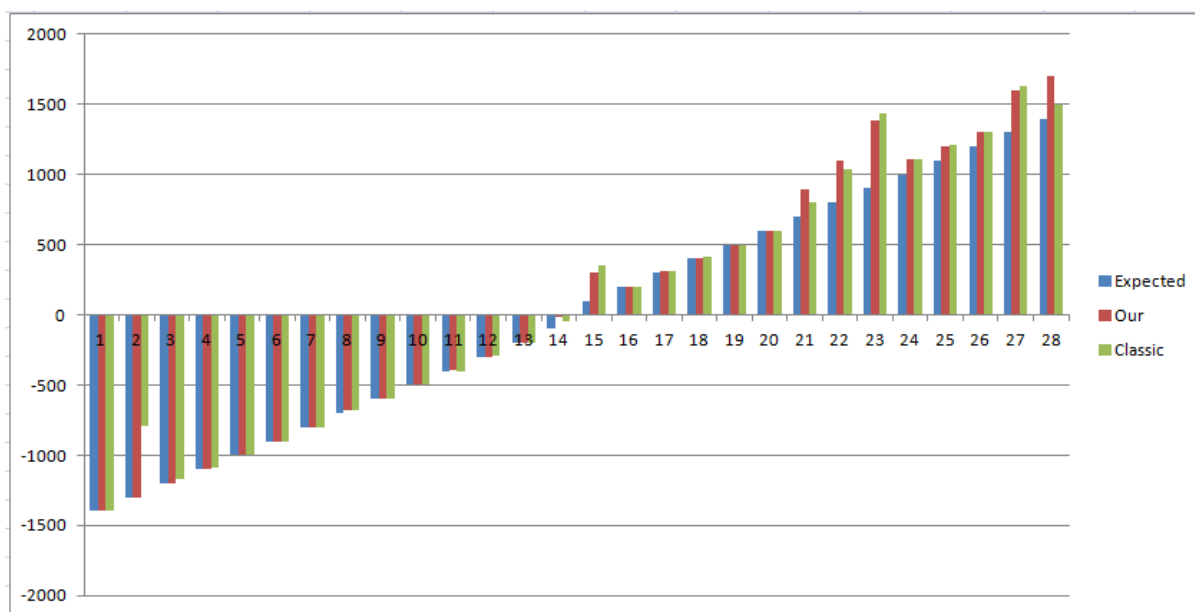
Rysunek 14: 5-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.75$, $Cr = 0.5$



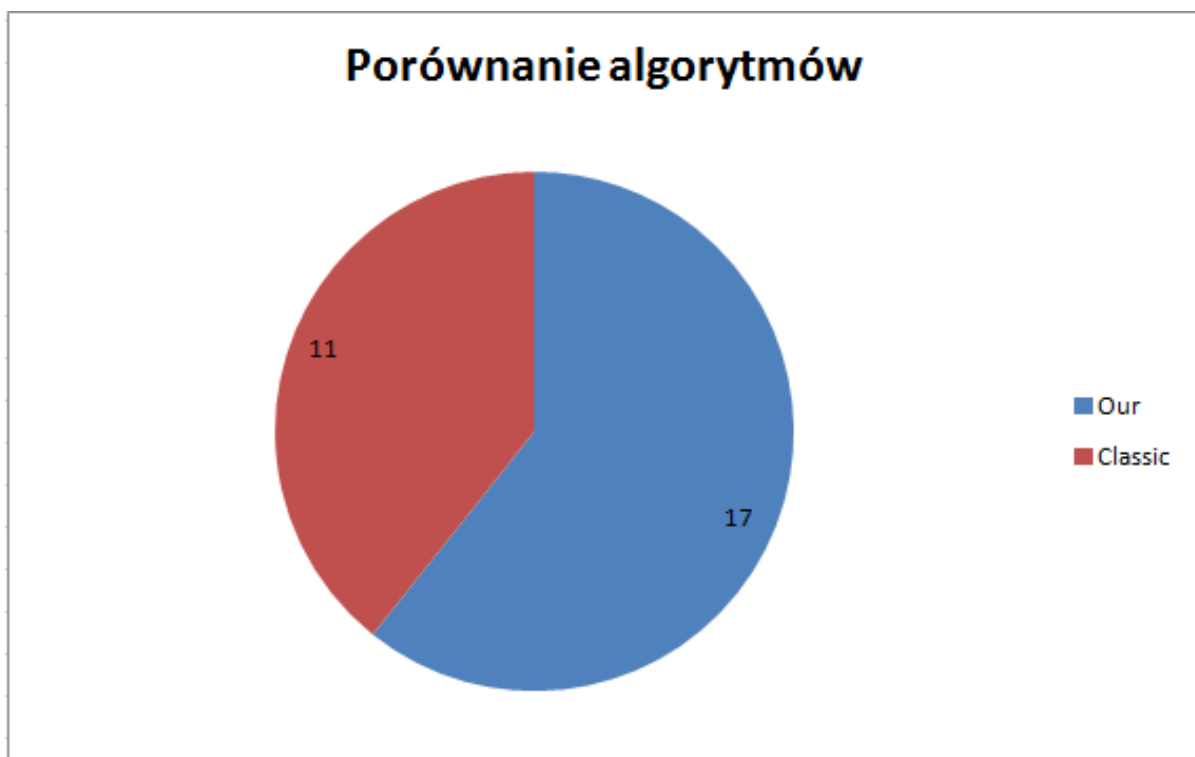
Rysunek 15: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | 0 | 7,51E-07 |
| 2 | -1300 | -1300 | -791,015 | -1299,99 | 727,9761 | -1300 | -791,015 | -1300 | -112,038 | -1300 | -118,068 | 0,001859 | 372,7973 |
| 3 | -1200 | -1200 | -1174,2 | -1199,96 | -1154,29 | -1200 | -1174,2 | -1199,99 | -1171,46 | -1199,98 | -1166,65 | 0,02178 | 10,79384 |
| 4 | -1100 | -1100 | -1088,19 | -1100 | -1039,9 | -1100 | -1088,19 | -1100 | -1059,46 | -1100 | -1062,59 | 6,04E-05 | 14,81624 |
| 5 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | 0 | 1,25E-05 |
| 6 | -900 | -899,842 | -899,993 | -897,911 | -899,969 | -899,842 | -899,993 | -899,589 | -899,984 | -899,404 | -899,982 | 0,552674 | 0,006516 |
| 7 | -800 | -799,999 | -799,758 | -799,999 | -799,663 | -799,999 | -799,758 | -799,999 | -799,709 | -799,999 | -799,71 | 0,000211 | 0,047246 |
| 8 | -700 | -681,325 | -681,764 | -679,913 | -679,887 | -681,325 | -681,764 | -680,258 | -679,944 | -680,507 | -680,18 | 0,593663 | 0,596981 |
| 9 | -600 | -598,142 | -598,311 | -597,253 | -597,425 | -598,142 | -598,311 | -597,704 | -598,207 | -597,699 | -597,981 | 0,444706 | 0,484633 |
| 10 | -500 | -499,927 | -499,886 | -499,782 | -499,571 | -499,927 | -499,886 | -499,878 | -499,69 | -499,869 | -499,704 | 0,046456 | 0,101164 |
| 11 | -400 | -395,986 | -399,161 | -395,051 | -396,583 | -395,986 | -399,161 | -395,435 | -397,11 | -395,49 | -397,618 | 0,47019 | 1,362018 |
| 12 | -300 | -297,222 | -294,872 | -294,399 | -291,496 | -297,222 | -294,872 | -296,008 | -292,903 | -295,823 | -292,908 | 0,909424 | 1,171595 |
| 13 | -200 | -199,378 | -196,463 | -193,677 | -189,74 | -199,378 | -196,463 | -195,433 | -190,229 | -196,163 | -192,144 | 2,919733 | 3,748099 |
| 14 | -100 | -14,5728 | -44,0822 | 99,07942 | 29,34322 | -14,5728 | -44,0822 | 41,14872 | 3,734683 | 42,20246 | 0,984359 | 35,78269 | 27,04602 |
| 15 | 100 | 305,8923 | 356,6035 | 395,5426 | 579,91 | 305,8923 | 356,6035 | 346,152 | 481,0478 | 349,1957 | 472,5204 | 44,90258 | 111,8972 |
| 16 | 200 | 200,6101 | 200,544 | 201,2273 | 201,5633 | 200,6101 | 200,544 | 200,8808 | 200,9435 | 200,886 | 200,9821 | 0,233536 | 0,306667 |
| 17 | 300 | 306,7918 | 308,8648 | 307,5536 | 311,9687 | 306,7918 | 308,8648 | 307,059 | 309,0363 | 307,1348 | 309,9566 | 0,386546 | 1,744634 |
| 18 | 400 | 407,8169 | 411,7178 | 411,1888 | 414,8282 | 407,8169 | 411,7178 | 409,055 | 413,8126 | 409,2492 | 413,5056 | 1,192571 | 1,034694 |
| 19 | 500 | 500,3571 | 500,3426 | 500,4736 | 500,673 | 500,3571 | 500,3426 | 500,4579 | 500,3891 | 500,4295 | 500,4682 | 0,063184 | 0,178837 |
| 20 | 600 | 600,4777 | 600,4439 | 600,9725 | 601,1893 | 600,4777 | 600,4439 | 600,6017 | 601,0855 | 600,6502 | 600,9818 | 0,153551 | 0,226496 |
| 21 | 700 | 898,0333 | 800,8527 | 1000 | 1000,022 | 898,0333 | 800,8527 | 1000 | 1000,016 | 966,0111 | 933,6304 | 58,87052 | 114,9889 |
| 22 | 800 | 1095,012 | 1040,445 | 1307,034 | 1234,147 | 1095,012 | 1040,445 | 1213,495 | 1169,243 | 1203,22 | 1155,978 | 70,75198 | 59,50289 |
| 23 | 900 | 1381,068 | 1432,554 | 1386,935 | 1591,017 | 1381,068 | 1432,554 | 1385,035 | 1515,652 | 1384,346 | 1513,075 | 2,993615 | 79,26289 |
| 24 | 1000 | 1110,533 | 1111,098 | 1119,801 | 1122,194 | 1110,533 | 1111,098 | 1117,156 | 1117,847 | 1116,382 | 1117,475 | 3,022075 | 2,834872 |
| 25 | 1100 | 1203,153 | 1208,539 | 1207,13 | 1209,53 | 1203,153 | 1208,539 | 1205,989 | 1208,911 | 1205,424 | 1208,993 | 2,047721 | 0,501017 |
| 26 | 1200 | 1303,957 | 1304,25 | 1307,599 | 1311,692 | 1303,957 | 1304,25 | 1305,242 | 1307,8 | 1305,643 | 1307,585 | 1,301178 | 2,172317 |
| 27 | 1300 | 1600,193 | 1625,421 | 1600,674 | 1659,829 | 1600,193 | 1625,421 | 1600,395 | 1643,593 | 1600,421 | 1642,948 | 0,241796 | 17,21309 |
| 28 | 1400 | 1700 | 1500,211 | 1700 | 1700,012 | 1700 | 1500,211 | 1700 | 1700,006 | 1700 | 1660,05 | 5,43E-07 | 84,23767 |

Rysunek 16: 5-wymiarowa populacja. Wyniki dla parametrów: $F = 0.75$, $Cr = 0.75$



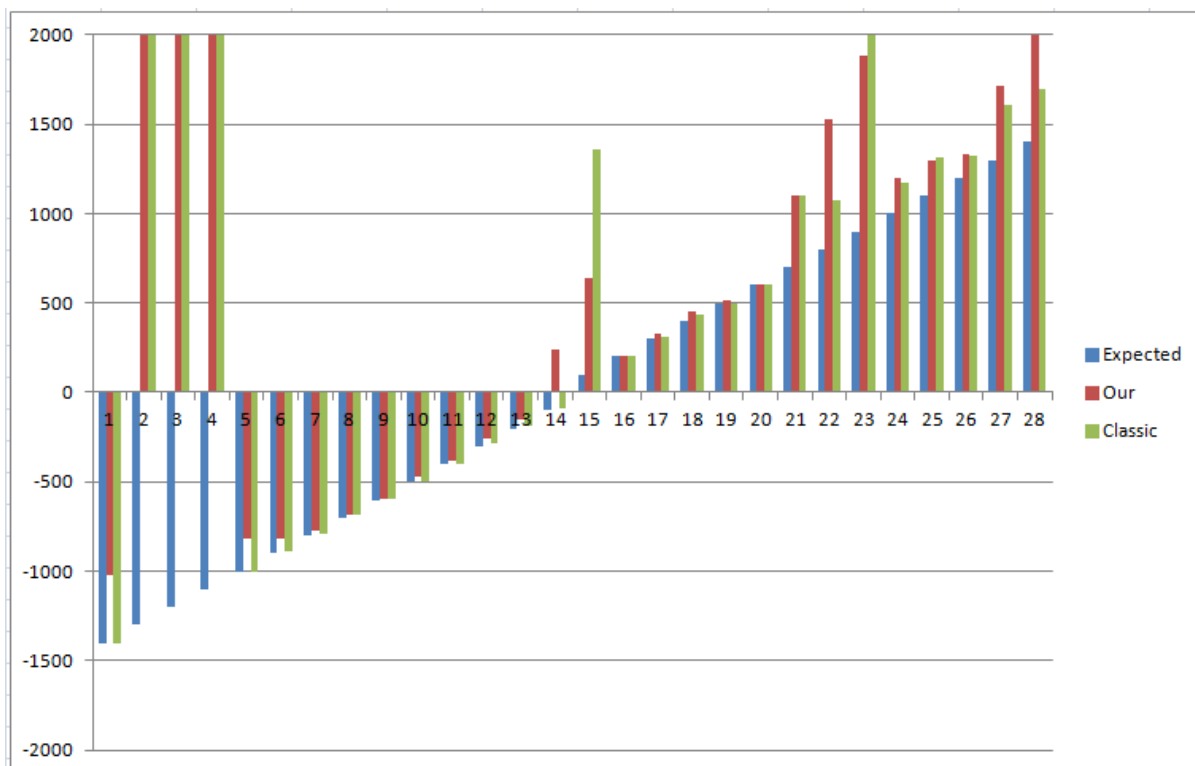
Rysunek 17: 5-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.75$, $Cr = 0.75$



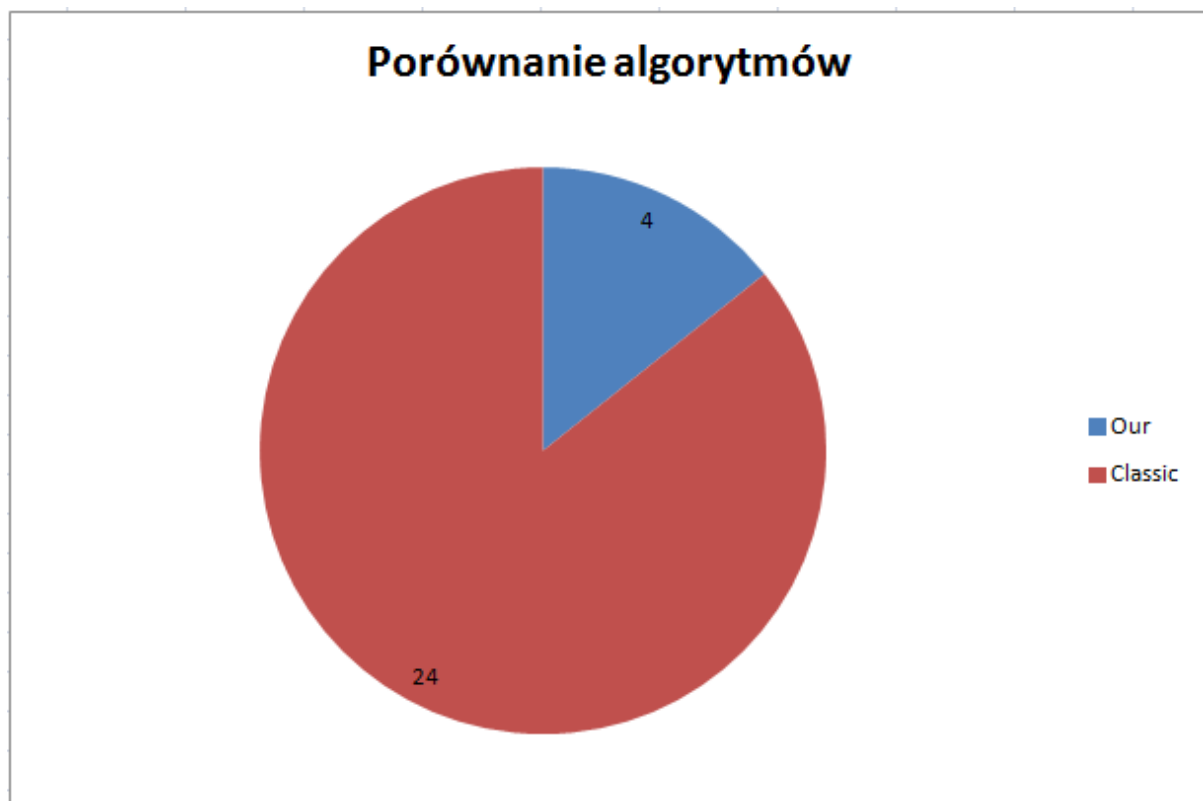
Rysunek 18: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|---------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1023,65 | -1400 | -699,16 | -1400 | -1023,65 | -1400 | -875,961 | -1400 | -880,827 | -1400 | 106,588 | 0 |
| 2 | -1300 | 2560105 | 1015880 | 6323053 | 5337731 | 2560105 | 1015880 | 4678441 | 3319105 | 4754354 | 3025406 | 1233952 | 1367760 |
| 3 | -1200 | 2,6E+08 | 81392,4 | 1,5E+09 | 2369625 | 2,6E+08 | 81392,4 | 8,9E+08 | 810745 | 9,2E+08 | 940504 | 4,5E+08 | 768939 |
| 4 | -1100 | 7864,39 | 8832,69 | 13477,6 | 25971,7 | 7864,39 | 8832,69 | 10795,3 | 15889,5 | 10793,9 | 15552 | 1650,54 | 5253,5 |
| 5 | -1000 | -819,908 | -1000 | -575,828 | -1000 | -819,908 | -1000 | -693,512 | -1000 | -690,863 | -1000 | 88,9898 | 3E-12 |
| 6 | -900 | -820,048 | -890,092 | -794,582 | -889,884 | -820,048 | -890,092 | -812,947 | -889,987 | -812,201 | -889,986 | 7,11859 | 0,07703 |
| 7 | -800 | -774,661 | -793,728 | -735,931 | -779,23 | -774,661 | -793,728 | -751,881 | -790,392 | -752,045 | -788,822 | 12,4283 | 4,65585 |
| 8 | -700 | -679,713 | -679,791 | -679,447 | -679,474 | -679,713 | -679,791 | -679,517 | -679,586 | -679,543 | -679,609 | 0,08006 | 0,09564 |
| 9 | -600 | -594,267 | -594,724 | -592,186 | -591,985 | -594,267 | -594,724 | -593,603 | -592,523 | -593,393 | -592,775 | 0,72414 | 0,7654 |
| 10 | -500 | -473,189 | -498,772 | -379,504 | -497,479 | -473,189 | -498,772 | -431,751 | -498,542 | -426,747 | -498,407 | 30,5622 | 0,41215 |
| 11 | -400 | -378,451 | -400 | -353,294 | -400 | -378,451 | -400 | -365,273 | -400 | -365,341 | -400 | 7,66501 | 2,7E-05 |
| 12 | -300 | -255,63 | -281,413 | -231,293 | -267,822 | -255,63 | -281,413 | -246,398 | -272,944 | -245,968 | -273,423 | 7,02025 | 4,12306 |
| 13 | -200 | -148,804 | -186,693 | -126,946 | -166,301 | -148,804 | -186,693 | -141,83 | -175,35 | -139,963 | -175,069 | 7,68667 | 5,98469 |
| 14 | -100 | 241,902 | -88,9565 | 475,536 | -48,501 | 241,902 | -88,9565 | 329,668 | -73,9745 | 330,476 | -72,4319 | 65,3575 | 13,2391 |
| 15 | 100 | 637,201 | 1355,6 | 1151,01 | 1701,4 | 637,201 | 1355,6 | 881,405 | 1579,3 | 891,173 | 1563,57 | 145,392 | 112,571 |
| 16 | 200 | 200,834 | 200,676 | 201,552 | 201,469 | 200,834 | 200,676 | 201,218 | 201,197 | 201,249 | 201,181 | 0,23852 | 0,23091 |
| 17 | 300 | 332,516 | 312,794 | 343,678 | 315,659 | 332,516 | 312,794 | 336,349 | 314,437 | 336,935 | 314,406 | 3,78873 | 1,00359 |
| 18 | 400 | 450,524 | 435,926 | 460,907 | 443,899 | 450,524 | 435,926 | 459,186 | 440,037 | 458,383 | 440,048 | 3,15974 | 3,01572 |
| 19 | 500 | 519,264 | 500,695 | 588,204 | 501,245 | 519,264 | 500,695 | 541,585 | 500,958 | 550,115 | 500,96 | 28,2535 | 0,16905 |
| 20 | 600 | 603,177 | 603,042 | 603,484 | 603,769 | 603,177 | 603,042 | 603,358 | 603,368 | 603,366 | 603,38 | 0,09654 | 0,2148 |
| 21 | 700 | 1104,99 | 1100,19 | 1122,04 | 1100,19 | 1104,99 | 1100,19 | 1116,06 | 1100,19 | 1113,92 | 1100,19 | 6,04896 | 0 |
| 22 | 800 | 1531,31 | 1071,47 | 1942,13 | 1302,38 | 1531,31 | 1071,47 | 1878,3 | 1134,13 | 1788 | 1146,28 | 155,139 | 65,6375 |
| 23 | 900 | 1885,19 | 2329,41 | 2623,74 | 2732,24 | 1885,19 | 2329,41 | 2263,01 | 2579,74 | 2301,83 | 2571,4 | 213,225 | 132,55 |
| 24 | 1000 | 1200,48 | 1175,09 | 1228,79 | 1219,97 | 1200,48 | 1175,09 | 1222,35 | 1215,2 | 1220,84 | 1206,94 | 7,72614 | 15,7367 |
| 25 | 1100 | 1297,25 | 1309,99 | 1323,57 | 1318,73 | 1297,25 | 1309,99 | 1318,84 | 1315,62 | 1317,07 | 1315,35 | 7,54455 | 2,4004 |
| 26 | 1200 | 1330,65 | 1324,67 | 1381,96 | 1358,48 | 1330,65 | 1324,67 | 1348,72 | 1349,82 | 1352,51 | 1345,04 | 16,3597 | 11,3797 |
| 27 | 1300 | 1713,61 | 1609,06 | 1794,98 | 1765,95 | 1713,61 | 1609,06 | 1730,62 | 1699,74 | 1736,77 | 1690,12 | 23,4177 | 55,7232 |
| 28 | 1400 | 2158,8 | 1700 | 2246,96 | 1700 | 2158,8 | 1700 | 2212,32 | 1700 | 2206,38 | 1700 | 25,5215 | 1,1E-06 |

Rysunek 19: 10-wymiarowa populacja. Wyniki dla parametrów: $F = 0.25$, $Cr = 0.25$



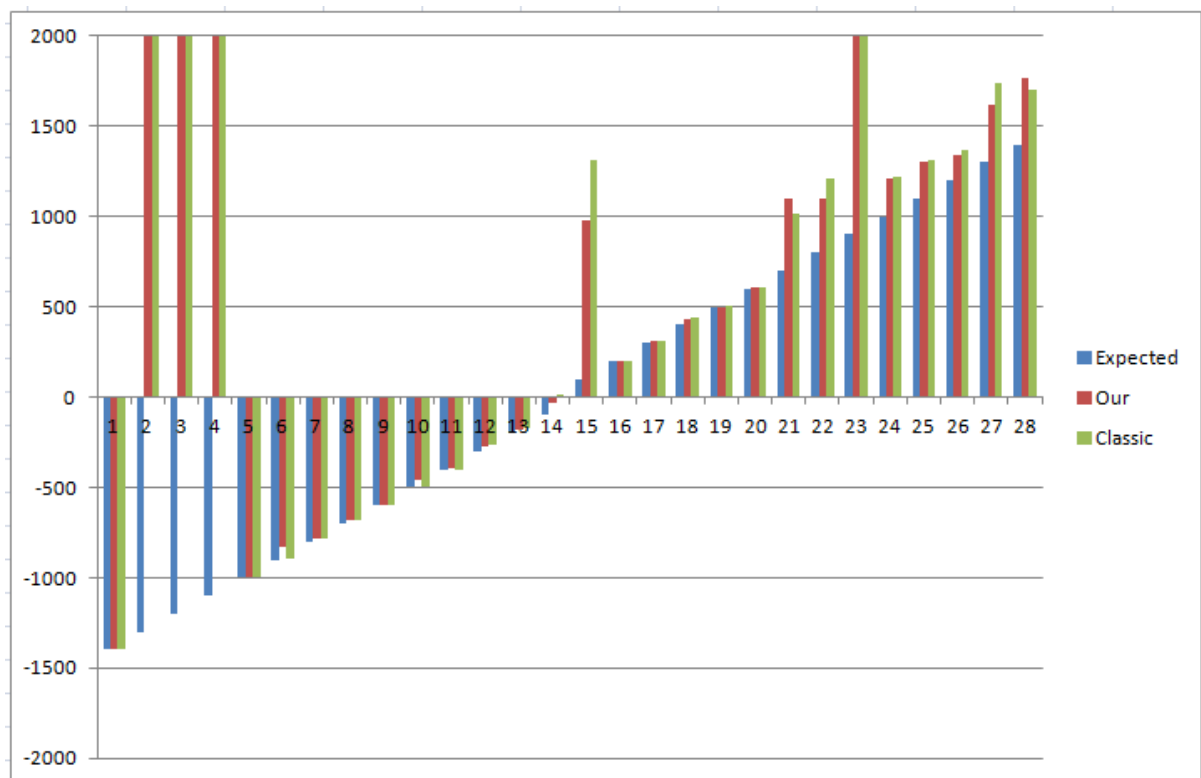
Rysunek 20: 10-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.25$, $Cr = 0.25$



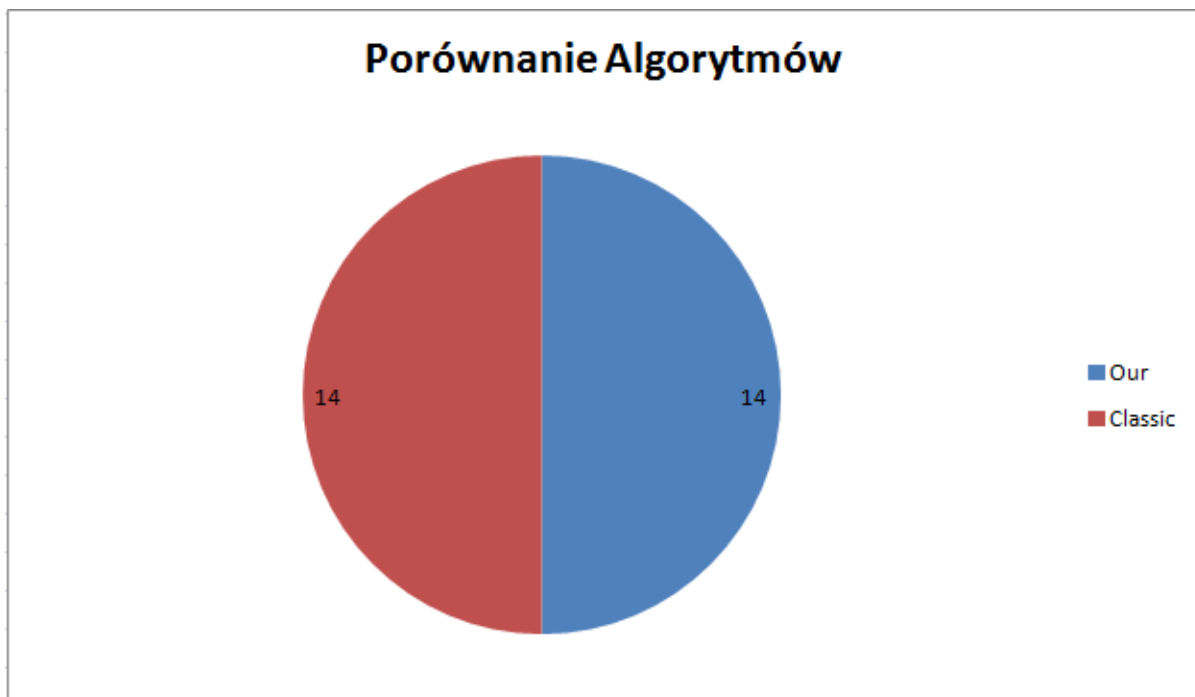
Rysunek 21: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|---------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1399,96 | -1400 | -1394,14 | -1400 | -1399,96 | -1400 | -1399,53 | -1400 | -1399,01 | -1400 | 1,75775 | 8,7E-12 |
| 2 | -1300 | 1824962 | 1387474 | 3879225 | 8157824 | 1824962 | 1387474 | 3074265 | 4937522 | 2890737 | 5022508 | 684813 | 1989861 |
| 3 | -1200 | 6,1E+07 | 8209910 | 4,9E+08 | 4,3E+07 | 6,1E+07 | 8209910 | 1,2E+08 | 2,3E+07 | 1,6E+08 | 2,2E+07 | 1,2E+08 | 9889124 |
| 4 | -1100 | 5515,68 | 7320,31 | 10550,4 | 24317,6 | 5515,68 | 7320,31 | 8573,86 | 14197,6 | 8315,02 | 14664,5 | 1489,54 | 5513,92 |
| 5 | -1000 | -999,707 | -1000 | -978,443 | -1000 | -999,707 | -1000 | -995,697 | -1000 | -993,143 | -1000 | 6,83781 | 1,9E-08 |
| 6 | -900 | -827,517 | -890,186 | -805,158 | -890,168 | -827,517 | -890,186 | -823,455 | -890,186 | -821,921 | -890,183 | 6,59429 | 0,00576 |
| 7 | -800 | -779,877 | -782,094 | -770,507 | -772,114 | -779,877 | -782,094 | -776,208 | -777,546 | -775,005 | -777,265 | 3,49274 | 2,87071 |
| 8 | -700 | -679,675 | -679,702 | -679,508 | -679,469 | -679,675 | -679,702 | -679,625 | -679,587 | -679,614 | -679,576 | 0,05162 | 0,06319 |
| 9 | -600 | -594,778 | -593,515 | -592,771 | -591,984 | -594,778 | -593,515 | -593,608 | -592,442 | -593,609 | -592,637 | 0,53759 | 0,59339 |
| 10 | -500 | -462,506 | -498,687 | -457,772 | -498,521 | -462,506 | -498,687 | -460,139 | -498,604 | -460,139 | -498,604 | 3,34712 | 0,11745 |
| 11 | -400 | -395,841 | -399,997 | -392,08 | -399,715 | -395,841 | -399,997 | -394,426 | -399,896 | -394,209 | -399,881 | 1,15352 | 0,09071 |
| 12 | -300 | -278,088 | -268,171 | -271,721 | -266,266 | -278,088 | -268,171 | -274,905 | -267,219 | -274,905 | -267,219 | 4,5021 | 1,34696 |
| 13 | -200 | -184,156 | -175,613 | -169,899 | -160,541 | -184,156 | -175,613 | -178,286 | -168,617 | -177,58 | -168,598 | 4,66422 | 4,40092 |
| 14 | -100 | -34,9785 | 6,65801 | 259,088 | 11,9088 | -34,9785 | 6,65801 | 112,055 | 9,28338 | 112,055 | 9,28338 | 207,936 | 3,71284 |
| 15 | 100 | 981,829 | 1310,57 | 1483,62 | 1763,43 | 981,829 | 1310,57 | 1341,35 | 1669,01 | 1322,02 | 1597,65 | 151,439 | 152,89 |
| 16 | 200 | 201,227 | 201,344 | 201,657 | 201,37 | 201,227 | 201,344 | 201,442 | 201,357 | 201,442 | 201,357 | 0,30418 | 0,01839 |
| 17 | 300 | 314,145 | 312,076 | 318,009 | 313,11 | 314,145 | 312,076 | 315,733 | 312,404 | 316,067 | 312,461 | 1,3127 | 0,35926 |
| 18 | 400 | 426,835 | 436,283 | 434,951 | 446,686 | 426,835 | 436,283 | 430,893 | 441,485 | 430,893 | 441,485 | 5,73903 | 7,35562 |
| 19 | 500 | 500,607 | 501,122 | 501,828 | 501,435 | 500,607 | 501,122 | 501,188 | 501,277 | 501,15 | 501,278 | 0,36533 | 0,09227 |
| 20 | 600 | 603,384 | 603,334 | 603,46 | 603,511 | 603,384 | 603,334 | 603,422 | 603,423 | 603,422 | 603,423 | 0,05401 | 0,12499 |
| 21 | 700 | 1100,21 | 1015,24 | 1100,58 | 1100,19 | 1100,21 | 1015,24 | 1100,33 | 1100,19 | 1100,35 | 1084,82 | 0,12348 | 32,6428 |
| 22 | 800 | 1103,15 | 1207,87 | 1500,73 | 1464,17 | 1103,15 | 1207,87 | 1301,94 | 1336,02 | 1301,94 | 1336,02 | 281,137 | 181,23 |
| 23 | 900 | 2217,68 | 2063,11 | 2581,96 | 2756,11 | 2217,68 | 2063,11 | 2421,1 | 2607,63 | 2390,65 | 2563,31 | 129,81 | 202,306 |
| 24 | 1000 | 1210,9 | 1218,88 | 1213,88 | 1220,88 | 1210,9 | 1218,88 | 1212,39 | 1219,88 | 1212,39 | 1219,88 | 2,10608 | 1,41662 |
| 25 | 1100 | 1303,67 | 1315,18 | 1309,18 | 1321,54 | 1303,67 | 1315,18 | 1306,93 | 1319,44 | 1306,26 | 1318,71 | 2,12777 | 2,48243 |
| 26 | 1200 | 1343,2 | 1370,3 | 1349,25 | 1372,7 | 1343,2 | 1370,3 | 1346,23 | 1371,5 | 1346,23 | 1371,5 | 4,27964 | 1,69243 |
| 27 | 1300 | 1622,16 | 1741,58 | 1706,16 | 1843,91 | 1622,16 | 1741,58 | 1643,4 | 1832,65 | 1650,77 | 1809,91 | 25,5249 | 38,4067 |
| 28 | 1400 | 1770,92 | 1700 | 2109,66 | 1700 | 1770,92 | 1700 | 1940,29 | 1700 | 1940,29 | 1700 | 239,525 | 0,00028 |

Rysunek 22: 10-wymiarowa populacja. Wyniki dla parametrów: $F = 0.5$, $Cr = 0.25$



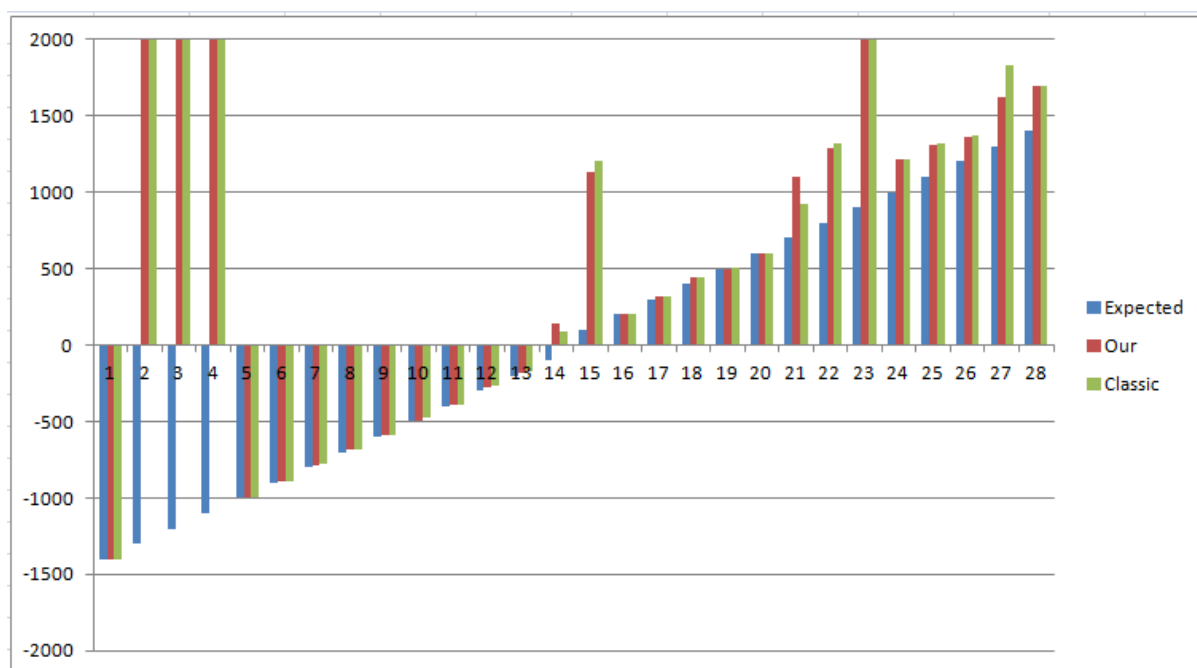
Rysunek 23: 10-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.5$, $Cr = 0.25$



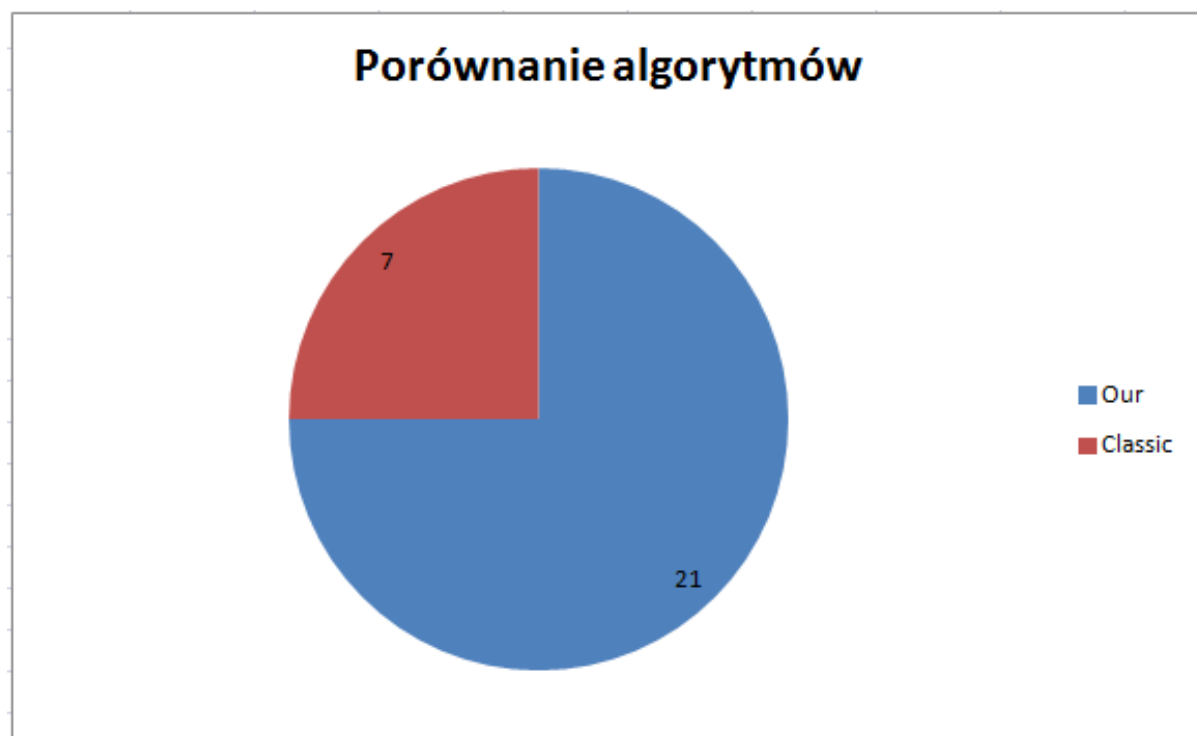
Rysunek 24: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|---------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | 0 | 4,6E-07 |
| 2 | -1300 | 3521987 | 7373565 | 6119127 | 8034552 | 3521987 | 7373565 | 4820557 | 7704058 | 4820557 | 7704058 | 1836455 | 467389 |
| 3 | -1200 | 5174951 | 1,2E+08 | 3,1E+07 | 2,4E+08 | 5174951 | 1,2E+08 | 9251344 | 1,6E+08 | 1,1E+07 | 1,7E+08 | 7644820 | 3,4E+07 |
| 4 | -1100 | 6336,16 | 8776,41 | 12406,2 | 23143,3 | 6336,16 | 8776,41 | 9371,19 | 15959,9 | 9371,19 | 15959,9 | 4292,18 | 10159 |
| 5 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | -1000 | 5,5E-12 | 2,5E-05 |
| 6 | -900 | -890,05 | -891,685 | -889,801 | -889,954 | -890,05 | -891,685 | -889,925 | -890,82 | -889,925 | -890,82 | 0,17581 | 1,22349 |
| 7 | -800 | -787,771 | -778,182 | -775,772 | -755,702 | -787,771 | -778,182 | -782,869 | -763,501 | -782,67 | -763,6 | 3,92294 | 6,40679 |
| 8 | -700 | -679,742 | -679,617 | -679,592 | -679,602 | -679,742 | -679,617 | -679,667 | -679,609 | -679,667 | -679,609 | 0,10562 | 0,01068 |
| 9 | -600 | -593,454 | -593,537 | -591,895 | -591,324 | -593,454 | -593,537 | -592,785 | -592,422 | -592,811 | -592,335 | 0,51165 | 0,64054 |
| 10 | -500 | -498,218 | -477,643 | -498,043 | -472,582 | -498,218 | -477,643 | -498,131 | -475,113 | -498,131 | -475,113 | 0,12354 | 3,57898 |
| 11 | -400 | -394,226 | -396,288 | -388,523 | -393,332 | -394,226 | -396,288 | -391,788 | -394,808 | -391,896 | -394,74 | 1,87226 | 1,08511 |
| 12 | -300 | -272,635 | -261,205 | -270,704 | -259,702 | -272,635 | -261,205 | -271,669 | -260,453 | -271,669 | -260,453 | 1,36523 | 1,06287 |
| 13 | -200 | -182,186 | -170,569 | -169,042 | -156,546 | -182,186 | -170,569 | -176,372 | -165,574 | -176,386 | -164,454 | 3,5436 | 4,71096 |
| 14 | -100 | 142,076 | 91,0851 | 282,367 | 96,1373 | 142,076 | 91,0851 | 212,221 | 93,6112 | 212,221 | 93,6112 | 99,2013 | 3,57247 |
| 15 | 100 | 1135,1 | 1200,35 | 1697,94 | 1727,03 | 1135,1 | 1200,35 | 1477,23 | 1572,87 | 1433,92 | 1524,63 | 180,705 | 182,148 |
| 16 | 200 | 201,365 | 201,051 | 201,511 | 201,229 | 201,365 | 201,051 | 201,438 | 201,14 | 201,438 | 201,14 | 0,10348 | 0,12621 |
| 17 | 300 | 313,794 | 318,478 | 317,396 | 322,562 | 313,794 | 318,478 | 315,756 | 320,386 | 315,594 | 320,4 | 0,9281 | 1,15919 |
| 18 | 400 | 442,145 | 443,429 | 443,685 | 446,999 | 442,145 | 443,429 | 442,915 | 445,214 | 442,915 | 445,214 | 1,08854 | 2,52425 |
| 19 | 500 | 500,741 | 500,931 | 501,149 | 501,743 | 500,741 | 500,931 | 501,049 | 501,495 | 501,012 | 501,403 | 0,12662 | 0,27178 |
| 20 | 600 | 603,524 | 603,282 | 603,554 | 603,765 | 603,524 | 603,282 | 603,539 | 603,523 | 603,539 | 603,523 | 0,02171 | 0,34132 |
| 21 | 700 | 1100,19 | 925,071 | 1100,26 | 1081,8 | 1100,19 | 925,071 | 1100,2 | 964,214 | 1100,2 | 988,933 | 0,01953 | 61,0154 |
| 22 | 800 | 1284,14 | 1321,56 | 1327,24 | 1431,94 | 1284,14 | 1321,56 | 1305,69 | 1376,75 | 1305,69 | 1376,75 | 30,4787 | 78,0469 |
| 23 | 900 | 2010,49 | 2424,66 | 2803,41 | 2826,18 | 2010,49 | 2424,66 | 2501,09 | 2520,98 | 2466,73 | 2554,83 | 223,329 | 125,732 |
| 24 | 1000 | 1217,96 | 1218,76 | 1220,76 | 1222,53 | 1217,96 | 1218,76 | 1219,36 | 1220,65 | 1219,36 | 1220,65 | 1,97936 | 2,66313 |
| 25 | 1100 | 1311,28 | 1315,53 | 1321,28 | 1323,8 | 1311,28 | 1315,53 | 1315,64 | 1321,47 | 1315,51 | 1321,09 | 2,79835 | 2,49518 |
| 26 | 1200 | 1361,2 | 1374,59 | 1368,68 | 1395,04 | 1361,2 | 1374,59 | 1364,94 | 1384,82 | 1364,94 | 1384,82 | 5,29169 | 14,4576 |
| 27 | 1300 | 1625,21 | 1826,41 | 1776,14 | 1862,87 | 1625,21 | 1826,41 | 1718,88 | 1859,62 | 1706,73 | 1855,6 | 44,4728 | 10,994 |
| 28 | 1400 | 1700,1 | 1700,17 | 1718,76 | 1700,6 | 1700,1 | 1700,17 | 1709,43 | 1700,38 | 1709,43 | 1700,38 | 13,192 | 0,30609 |

Rysunek 25: 10-wymiarowa populacja. Wyniki dla parametrów: $F = 0.75$, $Cr = 0.25$



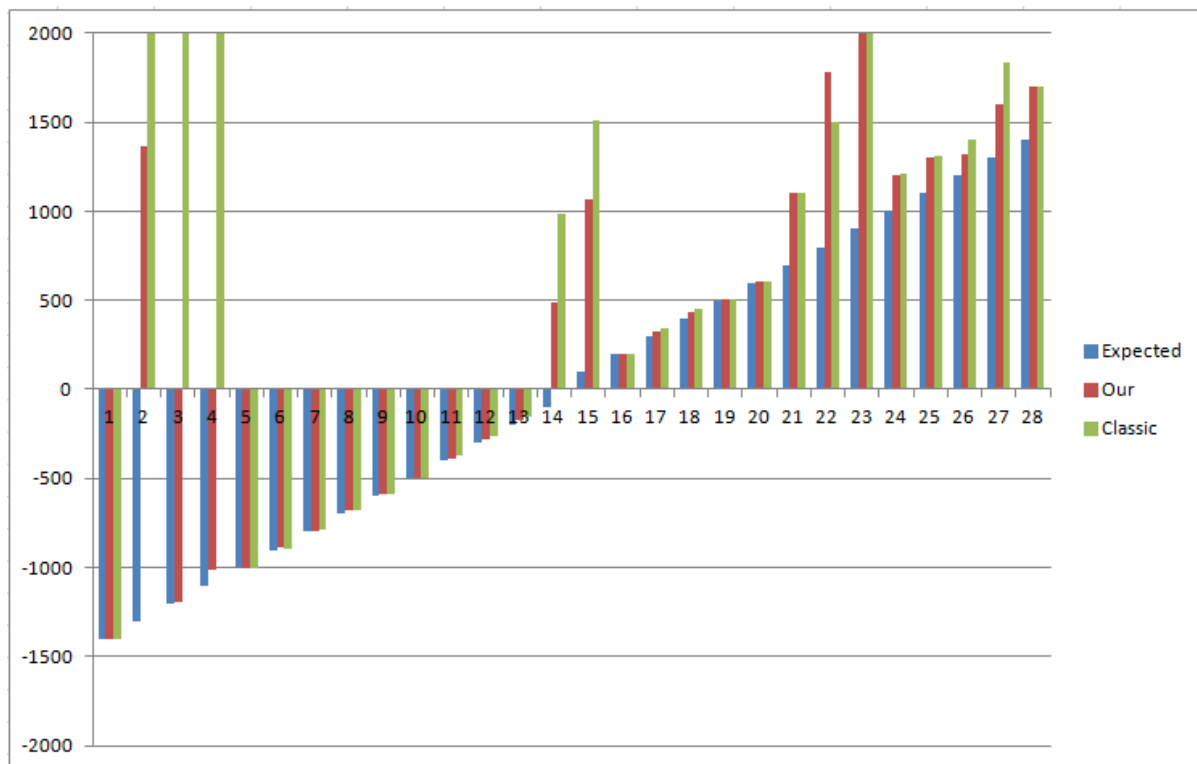
Rysunek 26: 10-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.75$, $Cr = 0.25$



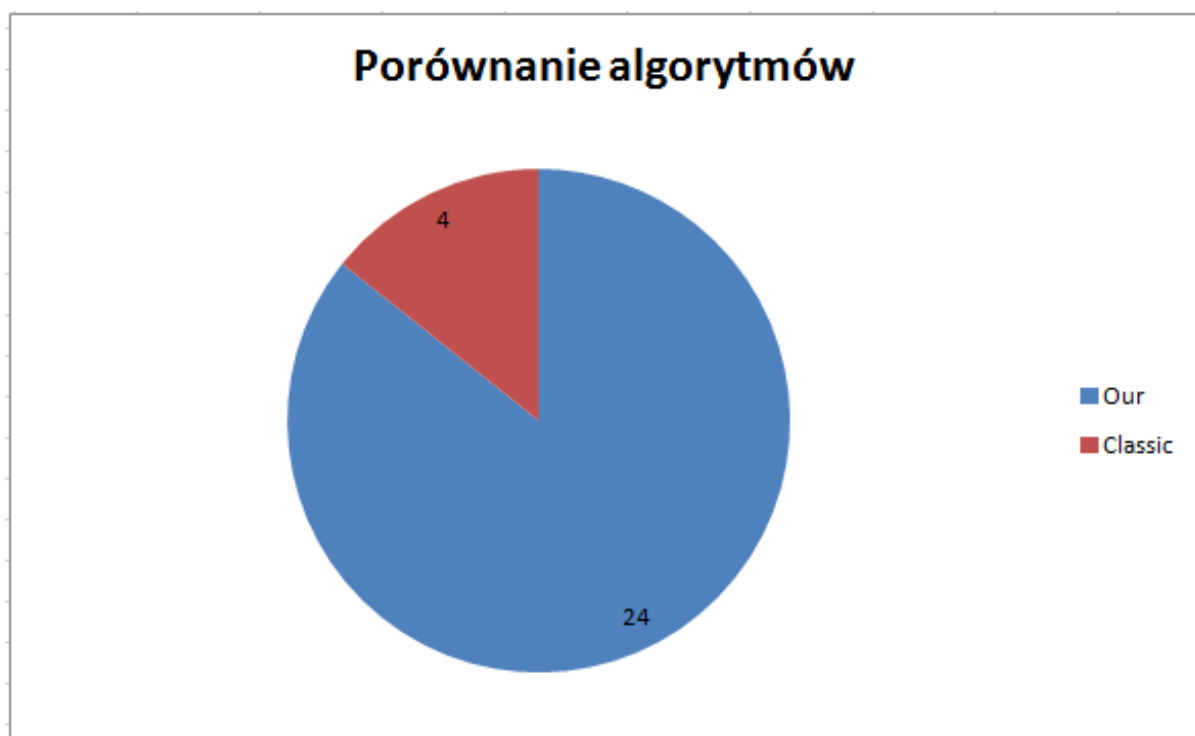
Rysunek 27: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

| Func | Expected | Best | | Max | | Min | | Median | | Mean | | Std | |
|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|---------|
| | | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic | Our | Classic |
| 1 | -1400 | -1400 | -1400 | -1400 | -1399,99 | -1400 | -1400 | -1400 | -1400 | -1400 | -1400 | 0 | 0,00392 |
| 2 | -1300 | 1363,44 | 1642182 | 10993,8 | 4270371 | 1363,44 | 1642182 | 6434,14 | 3444090 | 6569,71 | 3153709 | 3541,96 | 967762 |
| 3 | -1200 | -1190,59 | 2,8E+07 | -1186,87 | 1,3E+08 | -1190,59 | 2,8E+07 | -1188,73 | 7,8E+07 | -1188,73 | 7,8E+07 | 2,6294 | 7E+07 |
| 4 | -1100 | -1009,98 | 11392,9 | -514,082 | 25654,6 | -1009,98 | 11392,9 | -937,594 | 14266,7 | -897,099 | 16182,8 | 145,915 | 5178,8 |
| 5 | -1000 | -1000 | -999,985 | -1000 | -999,968 | -1000 | -999,985 | -1000 | -999,977 | -1000 | -999,977 | 0 | 0,01223 |
| 6 | -900 | -890,188 | -898,51 | -890,134 | -892,231 | -890,188 | -898,51 | -890,188 | -897,772 | -890,182 | -896,961 | 0,01693 | 2,00409 |
| 7 | -800 | -799,963 | -784,555 | -799,959 | -779,135 | -799,963 | -784,555 | -799,961 | -781,845 | -799,961 | -781,845 | 0,00295 | 3,8329 |
| 8 | -700 | -679,668 | -679,725 | -679,528 | -679,491 | -679,668 | -679,725 | -679,555 | -679,57 | -679,575 | -679,59 | 0,04654 | 0,08072 |
| 9 | -600 | -591,937 | -590,927 | -591,65 | -590,06 | -591,937 | -590,927 | -591,793 | -590,493 | -591,793 | -590,493 | 0,20282 | 0,61294 |
| 10 | -500 | -499,712 | -496,478 | -499,496 | -491,872 | -499,712 | -496,478 | -499,602 | -495,243 | -499,608 | -494,894 | 0,07038 | 1,47753 |
| 11 | -400 | -390,381 | -368,482 | -387,724 | -362,952 | -390,381 | -368,482 | -389,053 | -365,717 | -389,053 | -365,717 | 1,87839 | 3,90984 |
| 12 | -300 | -283,268 | -265,318 | -269,152 | -253,748 | -283,268 | -265,318 | -275,839 | -258,402 | -275,469 | -258,783 | 4,48598 | 4,45773 |
| 13 | -200 | -172,998 | -157,398 | -172,774 | -150,803 | -172,998 | -157,398 | -172,886 | -154,1 | -172,886 | -154,1 | 0,15823 | 4,66312 |
| 14 | -100 | 487,502 | 986,014 | 1110,6 | 1289,91 | 487,502 | 986,014 | 988,15 | 1148,05 | 920,587 | 1152,01 | 219,72 | 99,7072 |
| 15 | 100 | 1066,23 | 1507,18 | 1694,42 | 1558,94 | 1066,23 | 1507,18 | 1380,32 | 1533,06 | 1380,32 | 1533,06 | 444,195 | 36,5988 |
| 16 | 200 | 200,933 | 200,893 | 201,73 | 201,768 | 200,933 | 200,893 | 201,242 | 201,269 | 201,259 | 201,257 | 0,23715 | 0,33205 |
| 17 | 300 | 327,505 | 339,852 | 330,203 | 344,565 | 327,505 | 339,852 | 328,854 | 342,208 | 328,854 | 342,208 | 1,90793 | 3,33257 |
| 18 | 400 | 430,966 | 448,287 | 440,442 | 461,016 | 430,966 | 448,287 | 436,115 | 451,787 | 436,119 | 452,293 | 2,90811 | 4,1168 |
| 19 | 500 | 502,01 | 502,787 | 502,031 | 503,018 | 502,01 | 502,787 | 502,02 | 502,903 | 502,02 | 502,903 | 0,01472 | 0,1634 |
| 20 | 600 | 602,551 | 603,245 | 603,38 | 603,694 | 602,551 | 603,245 | 603,068 | 603,621 | 603,026 | 603,544 | 0,24352 | 0,14806 |
| 21 | 700 | 1100,19 | 1100,2 | 1100,19 | 1100,2 | 1100,19 | 1100,2 | 1100,19 | 1100,2 | 1100,19 | 1100,2 | 0 | 8,9E-05 |
| 22 | 800 | 1782,11 | 1503,17 | 2195,6 | 1900,08 | 1782,11 | 1503,17 | 1978,08 | 1750,8 | 1974,62 | 1724,57 | 133,189 | 125,365 |
| 23 | 900 | 2138,67 | 2266,36 | 2298,31 | 2721,27 | 2138,67 | 2266,36 | 2218,49 | 2493,82 | 2218,49 | 2493,82 | 112,884 | 321,673 |
| 24 | 1000 | 1200,03 | 1213,81 | 1219,37 | 1220,14 | 1200,03 | 1213,81 | 1210 | 1218,58 | 1208,5 | 1218,19 | 7,94685 | 1,97457 |
| 25 | 1100 | 1300,12 | 1313,07 | 1300,19 | 1323,91 | 1300,12 | 1313,07 | 1300,16 | 1318,49 | 1300,16 | 1318,49 | 0,04783 | 7,66248 |
| 26 | 1200 | 1319,41 | 1400,06 | 1400,02 | 1400,13 | 1319,41 | 1400,06 | 1353,5 | 1400,09 | 1358,24 | 1400,08 | 29,336 | 0,02144 |
| 27 | 1300 | 1600,15 | 1831,46 | 1600,2 | 1842,5 | 1600,15 | 1831,46 | 1600,17 | 1836,98 | 1600,17 | 1836,98 | 0,03484 | 7,80633 |
| 28 | 1400 | 1700 | 1702,32 | 1700 | 1702,69 | 1700 | 1702,32 | 1700 | 1702,5 | 1700 | 1702,5 | 1,3E-10 | 0,25548 |

Rysunek 28: 10-wymiarowa populacja. Wyniki dla parametrów: $F = 0.75$, $Cr = 0.75$



Rysunek 29: 10-wymiarowa populacja. Wykres porównujący najlepsze rozwiązania dla naszego algorytmu oraz klasycznego. Parametry: $F = 0.75$, $Cr = 0.75$



Rysunek 30: 5-wymiarowa populacja. Parametry: $F = 0.25$, $Cr = 0.25$. Wykres porównujący liczbę lepiej znalezionych rozwiązań pomiędzy dwoma algorytmami.

4 Wnioski

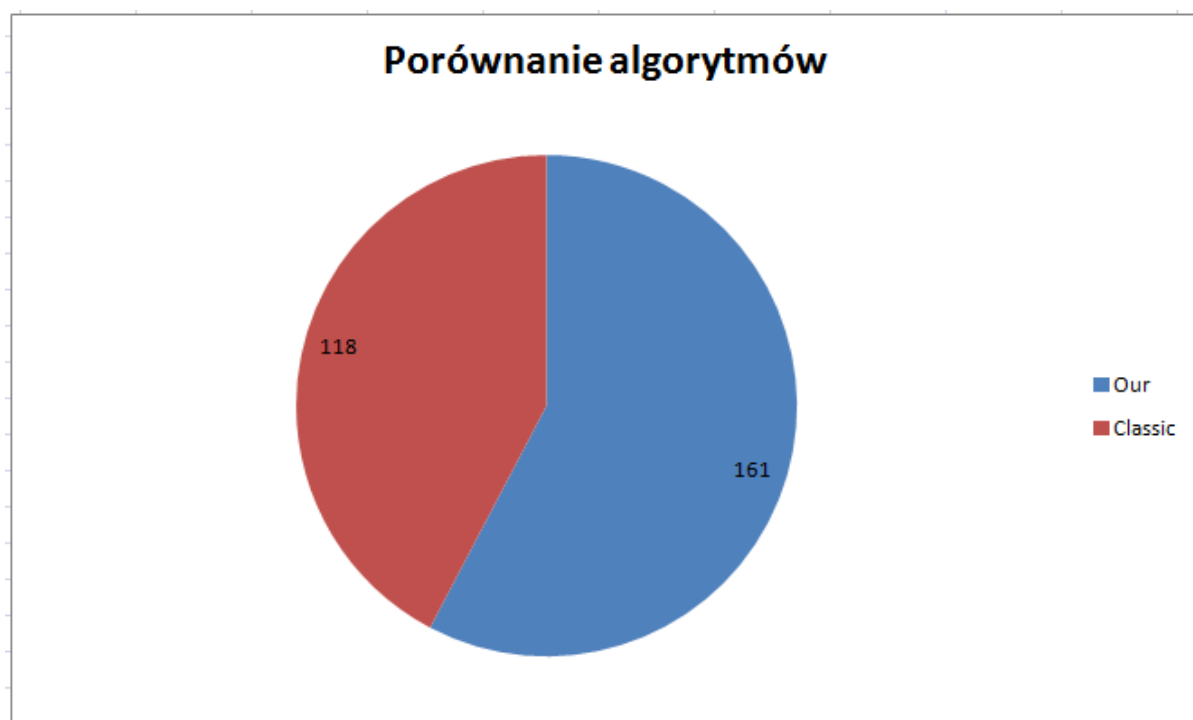
Zarówno algorytm klasyczny, jak i z wyborem elementu średniego zwracają porównywalne wyniki. Bardzo duże znaczenie na zwracane przez nie wyniki ma liczebność populacji początkowej oraz jej początkowe rozłożenie na przestrzeni rozwiązań.

Najbardziej problematycznymi funkcjami dla obu algorytmów okazały się funkcje o indeksach 2, 3, 4. Często dla tych funkcji algorytmy dawały znacznie gorsze wyniki od oczekiwanego rozwiązania. Bardziej podatny na tego typu błędy okazał się algorytm klasyczny.

Rozmiar wektora okazuje się mieć znaczenie na rozwiązanie. Dla wektorów 10-wymiarowych algorytmy częściej były podatne na pułapkę funkcji 2, 3, 4. Warto jednak zaznaczyć, że przyczyną tego może być fakt, że testowana liczebność populacji początkowej była równa dla obu wymiarów.

Współczynniki F i c_r okazują się mieć znaczenie na działanie algorytmów. Wartości dające najlepsze rezultaty to $F = 0.75$ i $c_r = 0.75$. Jest to zauważalne dla algorytmu z wyborem elementu średniego dla obu wymiarów. Z kolei wartości przynoszące najgorsze rezultaty to $F = 0.25$ i $c_r = 0.25$. Można to wynioskować na podstawie klasycznego algorytmu, który dla 10 wymiarów charakteryzuje się największą liczbą wartości znacznie odbiegających od oczekiwanych.

Podsumowując, oba algorytmy najlepiej działają dla mniejszej liczby wymiarów i dla współczynników $F = 0.75$ i $c_r = 0.75$. Dają dobre rezultaty, zbliżone bądź równe oczekiwanym wynikom. Częściej lepszy wynik zwracał algorytm z wyborem elementu średniego, co widać z wykresu 31.



Rysunek 31: Ogólne porównanie skuteczności obu algorytmów.