# GRASP

We can see that the Simple Randomized method gives a fairly decent result when there are no edge with negative weight. But performs very poorly when there are negative edges.

For the greedy approach we used two heuristics from this [paper](paper) for scoring.

SG1

$$score(i) \ = \ max( \ \sigma_x(i) \ , \ \sigma_y(i))$$

SG3

$$score(i) \ = \ | \ \sigma_x(i) \ - \ \sigma_y(i) \ |$$

Where

$$\sigma_x(v) \ = \ \sum_{u \in Y} w_{uv}$$

We used 20 iteration in the Semi-greedy and Randomized methods and took the avarage. We used 500 iteration in the GRASP.

We can see SG1 gives a better result than SG3 when approximating the max cut with greedy approach. But SG3 gives a better result than SG1 when approximating the max cut with Semi-Grady approach. Also SG3 performs better than SG1 in GRASP.

We can see the GRASP gives about 85% of the best known value when there are negative edges. But when there are no negative edges GRASP gives about 95% - 100% of the best known value.

For SG3 the number of avarage iterations is about half compared to SG1. This is because SG3 gives a better initial semi-greedy solution than SG1. So it converges to local optima faster.

▦ GRASP

| Name | |V| or n | |E| or m | min edge | max edge | Simple Randomized | Simple Greedy | Semi Greedy | Avg iterations | Avg improvements | Avg value | Iterations | Best Value | Known Best Solution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Problem** | | | | **Constructive algorithm** | | | **Local search** | | | **GRASP** | | **Known Best Solution** |
| G1 | 800 | 19176 | 1 | 1 | 9608 | 11265 | 11112 | 122 | 252 | 11371 | 500 | 11482 | 12078 |
| G2 | 800 | 19176 | 1 | 1 | 9568 | 11307 | 11113 | 119 | 247 | 11374 | 500 | 11482 | 12084 |
| G3 | 800 | 19176 | 1 | 1 | 9613 | 11225 | 11108 | 120 | 250 | 11368 | 500 | 11488 | 12077 |
| G4 | 800 | 19176 | 1 | 1 | 9583 | 11286 | 11144 | 122 | 254 | 11388 | 500 | 11531 | |
| G5 | 800 | 19176 | 1 | 1 | 9568 | 11233 | 11142 | 120 | 253 | 11376 | 500 | 11498 | |
| G6 | 800 | 19176 | -1 | 1 | 71 | 1701 | 1608 | 138 | 291 | 1917 | 500 | 2033 | |
| G7 | 800 | 19176 | -1 | 1 | -104 | 1654 | 1445 | 133 | 283 | 1743 | 500 | 1844 | |
| G8 | 800 | 19176 | -1 | 1 | -82 | 1588 | 1475 | 137 | 292 | 1751 | 500 | 1851 | |
| G9 | 800 | 19176 | -1 | 1 | -9 | 1713 | 1488 | 134 | 284 | 1790 | 500 | 1900 | |
| G10 | 800 | 19176 | -1 | 1 | -97 | 1668 | 1452 | 132 | 283 | 1744 | 500 | 1873 | |
| G11 | 800 | 1600 | -1 | 1 | 19 | 488 | 430 | 13 | 25 | 454 | 500 | 508 | 627 |
| G12 | 800 | 1600 | -1 | 1 | -3 | 480 | 413 | 13 | 25 | 442 | 500 | 490 | 621 |
| G13 | 800 | 1600 | -1 | 1 | 18 | 488 | 444 | 14 | 28 | 468 | 500 | 526 | 645 |
| G14 | 800 | 4694 | 1 | 1 | 2361 | 2951 | 2927 | 30 | 38 | 2960 | 500 | 2993 | 3187 |
| G15 | 800 | 4661 | 1 | 1 | 2335 | 2925 | 2900 | 30 | 38 | 2942 | 500 | 2973 | 3169 |
| G16 | 800 | 4672 | 1 | 1 | 2346 | 2950 | 2906 | 31 | 39 | 2946 | 500 | 2982 | 3172 |
| G17 | 800 | 4667 | 1 | 1 | 2324 | 2928 | 2908 | 30 | 38 | 2943 | 500 | 2980 | |
| G18 | 800 | 4694 | -1 | 1 | 30 | 835 | 728 | 63 | 102 | 843 | 500 | 913 | |
| G19 | 800 | 4661 | -1 | 1 | -47 | 744 | 657 | 63 | 103 | 759 | 500 | 832 | |
| G20 | 800 | 4672 | -1 | 1 | -11 | 776 | 702 | 60 | 98 | 789 | 500 | 862 | |
| G21 | 800 | 4667 | -1 | 1 | -41 | 753 | 676 | 65 | 105 | 782 | 500 | 846 | |
| G22 | 2000 | 19990 | 1 | 1 | 9995 | 12794 | 12603 | 170 | 300 | 12877 | 500 | 13015 | 14123 |
| G23 | 2000 | 19990 | 1 | 1 | 10018 | 12763 | 12609 | 174 | 308 | 12872 | 500 | 13025 | 14129 |
| G24 | 2000 | 19990 | 1 | 1 | 9997 | 12784 | 12534 | 170 | 301 | 12874 | 500 | 12997 | 14131 |
| G25 | 2000 | 19990 | 1 | 1 | 9978 | 12793 | 12610 | 168 | 297 | 12878 | 500 | 13019 | |
| G26 | 2000 | 19990 | 1 | 1 | 9961 | 12810 | 12670 | 173 | 304 | 12866 | 500 | 13009 | |
| G27 | 2000 | 19990 | -1 | 1 | -17 | 2613 | 2411 | 215 | 387 | 2840 | 500 | 2991 | |
| G28 | 2000 | 19990 | -1 | 1 | -58 | 2699 | 2470 | 216 | 392 | 2801 | 500 | 2950 | |
| G29 | 2000 | 19990 | -1 | 1 | -1 | 2744 | 2445 | 216 | 389 | 2896 | 500 | 3039 | |
| G30 | 2000 | 19990 | -1 | 1 | 49 | 2669 | 2473 | 216 | 392 | 2900 | 500 | 3063 | |
| G31 | 2000 | 19990 | -1 | 1 | -33 | 2692 | 2395 | 217 | 391 | 2816 | 500 | 2985 | |
| G32 | 2000 | 4000 | -1 | 1 | 10 | 1186 | 1078 | 33 | 66 | 1132 | 500 | 1234 | 1560 |
| G33 | 2000 | 4000 | -1 | 1 | -7 | 1176 | 1012 | 33 | 67 | 1103 | 500 | 1218 | 1537 |
| G34 | 2000 | 4000 | -1 | 1 | -22 | 1196 | 1036 | 34 | 68 | 1099 | 500 | 1220 | 1541 |
| G35 | 2000 | 11778 | 1 | 1 | 5879 | 7404 | 7348 | 68 | 88 | 7429 | 500 | 7499 | 8000 |
| G36 | 2000 | 11766 | 1 | 1 | 5882 | 7384 | 7345 | 70 | 90 | 7420 | 500 | 7478 | 7996 |
| G37 | 2000 | 11785 | 1 | 1 | 5894 | 7371 | 7341 | 70 | 90 | 7432 | 500 | 7487 | 8009 |
| G38 | 2000 | 11779 | 1 | 1 | 5894 | 7396 | 7347 | 70 | 91 | 7427 | 500 | 7485 | |
| G39 | 2000 | 11778 | -1 | 1 | -1 | 2011 | 1775 | 157 | 262 | 2040 | 500 | 2194 | |
| G40 | 2000 | 11766 | -1 | 1 | -37 | 2014 | 1794 | 156 | 260 | 2021 | 500 | 2158 | |
| G41 | 2000 | 11785 | -1 | 1 | -8 | 2050 | 1794 | 153 | 254 | 2027 | 500 | 2174 | |
| G42 | 2000 | 11779 | -1 | 1 | 62 | 2022 | 1864 | 159 | 266 | 2110 | 500 | 2248 | |
| G43 | 1000 | 9990 | 1 | 1 | 4987 | 6411 | 6265 | 89 | 158 | 6425 | 500 | 6533 | 7027 |
| G44 | 1000 | 9990 | 1 | 1 | 4988 | 6362 | 6245 | 87 | 152 | 6423 | 500 | 6517 | 7022 |
| G45 | 1000 | 9990 | 1 | 1 | 4994 | 6394 | 6259 | 83 | 146 | 6425 | 500 | 6503 | 7020 |
| G46 | 1000 | 9990 | 1 | 1 | 5000 | 6396 | 6288 | 86 | 153 | 6424 | 500 | 6505 | |
| G47 | 1000 | 9990 | 1 | 1 | 5016 | 6340 | 6291 | 90 | 158 | 6431 | 500 | 6534 | |
| G48 | 3000 | 6000 | 1 | 1 | 2987 | 6000 | 5255 | 29 | 65 | 5464 | 500 | 6000 | 6000 |
| G49 | 3000 | 6000 | 1 | 1 | 3001 | 6000 | 5453 | 29 | 64 | 5484 | 500 | 6000 | 6000 |
| G50 | 3000 | 6000 | 1 | 1 | 2986 | 5880 | 5251 | 28 | 63 | 5472 | 500 | 5880 | 5988 |
| G51 | 1000 | 5909 | 1 | 1 | 2959 | 3714 | 3676 | 37 | 46 | 3721 | 500 | 3757 | |
| G52 | 1000 | 5916 | 1 | 1 | 2949 | 3715 | 3680 | 37 | 47 | 3724 | 500 | 3767 | |
| G53 | 1000 | 5914 | 1 | 1 | 2956 | 3714 | 3669 | 34 | 44 | 3722 | 500 | 3763 | |
| G54 | 1000 | 5916 | 1 | 1 | 2963 | 3698 | 3671 | 36 | 46 | 3719 | 500 | 3754 | |

SG3-500

| Name | |V| or n | |E| or m | min edge | max edge | Simple Randomized | Simple Greedy | Semi Greedy | Avg iterations | Avg improvements | Avg value | Iterations | Best Value | Known Best Solution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Problem | | | | Constructive algorithm | | | Local search | | | GRASP | | Known Best Solution |
| G1 | 800 | 19176 | 1 | 1 | 9580 | 11070 | 11288 | 62 | 124 | 11407 | 500 | 11531 | 12078 |
| G2 | 800 | 19176 | 1 | 1 | 9589 | 11273 | 11265 | 63 | 129 | 11412 | 500 | 11552 | 12084 |
| G3 | 800 | 19176 | 1 | 1 | 9598 | 11249 | 11297 | 59 | 118 | 11406 | 500 | 11543 | 12077 |
| G4 | 800 | 19176 | 1 | 1 | 9580 | 11010 | 11286 | 60 | 121 | 11427 | 500 | 11540 | |
| G5 | 800 | 19176 | 1 | 1 | 9594 | 11010 | 11289 | 61 | 124 | 11414 | 500 | 11550 | |
| G6 | 800 | 19176 | -1 | 1 | 77 | 1551 | 1850 | 66 | 135 | 1956 | 500 | 2097 | |
| G7 | 800 | 19176 | -1 | 1 | -73 | 1535 | 1683 | 64 | 131 | 1793 | 500 | 1895 | |
| G8 | 800 | 19176 | -1 | 1 | -106 | 1521 | 1689 | 63 | 129 | 1803 | 500 | 1911 | |
| G9 | 800 | 19176 | -1 | 1 | -66 | 1521 | 1687 | 65 | 132 | 1837 | 500 | 1948 | |
| G10 | 800 | 19176 | -1 | 1 | -86 | 1422 | 1631 | 62 | 129 | 1789 | 500 | 1882 | |
| G11 | 800 | 1600 | -1 | 1 | 9 | 414 | 469 | 6 | 11 | 488 | 500 | 536 | 627 |
| G12 | 800 | 1600 | -1 | 1 | 0 | 452 | 484 | 6 | 11 | 480 | 500 | 528 | 621 |
| G13 | 800 | 1600 | -1 | 1 | 16 | 408 | 502 | 7 | 13 | 501 | 500 | 554 | 645 |
| G14 | 800 | 4694 | 1 | 1 | 2347 | 2938 | 2937 | 19 | 23 | 2976 | 500 | 3017 | 3187 |
| G15 | 800 | 4661 | 1 | 1 | 2345 | 2862 | 2939 | 17 | 21 | 2960 | 500 | 2998 | 3169 |
| G16 | 800 | 4672 | 1 | 1 | 2342 | 2912 | 2954 | 19 | 24 | 2961 | 500 | 3003 | 3172 |
| G17 | 800 | 4667 | 1 | 1 | 2331 | 2893 | 2929 | 20 | 25 | 2958 | 500 | 3010 | |
| G18 | 800 | 4694 | -1 | 1 | 25 | 695 | 879 | 25 | 38 | 890 | 500 | 960 | |
| G19 | 800 | 4661 | -1 | 1 | -66 | 605 | 791 | 24 | 37 | 809 | 500 | 875 | |
| G20 | 800 | 4672 | -1 | 1 | -22 | 730 | 805 | 24 | 36 | 837 | 500 | 905 | |
| G21 | 800 | 4667 | -1 | 1 | -47 | 653 | 791 | 25 | 38 | 830 | 500 | 892 | |
| G22 | 2000 | 19990 | 1 | 1 | 10014 | 12667 | 12794 | 95 | 165 | 12954 | 500 | 13152 | 14123 |
| G23 | 2000 | 19990 | 1 | 1 | 9981 | 12817 | 12820 | 93 | 162 | 12959 | 500 | 13107 | 14129 |
| G24 | 2000 | 19990 | 1 | 1 | 9993 | 12402 | 12802 | 90 | 155 | 12962 | 500 | 13108 | 14131 |
| G25 | 2000 | 19990 | 1 | 1 | 10010 | 12392 | 12787 | 91 | 156 | 12965 | 500 | 13149 | |
| G26 | 2000 | 19990 | 1 | 1 | 9991 | 12326 | 12812 | 98 | 169 | 12945 | 500 | 13129 | |
| G27 | 2000 | 19990 | -1 | 1 | -13 | 2741 | 2790 | 102 | 178 | 2946 | 500 | 3135 | |
| G28 | 2000 | 19990 | -1 | 1 | -55 | 2478 | 2762 | 96 | 168 | 2913 | 500 | 3088 | |
| G29 | 2000 | 19990 | -1 | 1 | 48 | 2621 | 2889 | 99 | 173 | 3008 | 500 | 3188 | |
| G30 | 2000 | 19990 | -1 | 1 | 77 | 2562 | 2772 | 99 | 172 | 3017 | 500 | 3199 | |
| G31 | 2000 | 19990 | -1 | 1 | -19 | 2686 | 2635 | 94 | 163 | 2932 | 500 | 3109 | |
| G32 | 2000 | 4000 | -1 | 1 | 10 | 1098 | 1136 | 17 | 34 | 1210 | 500 | 1314 | 1560 |
| G33 | 2000 | 4000 | -1 | 1 | -11 | 968 | 1211 | 17 | 33 | 1187 | 500 | 1300 | 1537 |
| G34 | 2000 | 4000 | -1 | 1 | -40 | 950 | 1158 | 17 | 33 | 1189 | 500 | 1296 | 1541 |
| G35 | 2000 | 11778 | 1 | 1 | 5883 | 7354 | 7455 | 43 | 55 | 7470 | 500 | 7566 | 8000 |
| G36 | 2000 | 11766 | 1 | 1 | 5875 | 7376 | 7379 | 39 | 49 | 7468 | 500 | 7546 | 7996 |
| G37 | 2000 | 11785 | 1 | 1 | 5898 | 7377 | 7438 | 40 | 51 | 7477 | 500 | 7571 | 8009 |
| G38 | 2000 | 11779 | 1 | 1 | 5888 | 7326 | 7376 | 40 | 50 | 7474 | 500 | 7554 | |
| G39 | 2000 | 11778 | -1 | 1 | 12 | 1752 | 2145 | 52 | 80 | 2172 | 500 | 2303 | |
| G40 | 2000 | 11766 | -1 | 1 | -53 | 1891 | 2048 | 51 | 79 | 2154 | 500 | 2287 | |
| G41 | 2000 | 11785 | -1 | 1 | -18 | 1682 | 2096 | 49 | 76 | 2160 | 500 | 2285 | |
| G42 | 2000 | 11779 | -1 | 1 | 45 | 1787 | 2167 | 50 | 78 | 2239 | 500 | 2365 | |
| G43 | 1000 | 9990 | 1 | 1 | 4984 | 6332 | 6335 | 47 | 80 | 6466 | 500 | 6560 | 7027 |
| G44 | 1000 | 9990 | 1 | 1 | 4989 | 6225 | 6319 | 48 | 82 | 6464 | 500 | 6567 | 7022 |
| G45 | 1000 | 9990 | 1 | 1 | 5011 | 6243 | 6412 | 52 | 89 | 6459 | 500 | 6563 | 7020 |
| G46 | 1000 | 9990 | 1 | 1 | 5003 | 6121 | 6360 | 48 | 84 | 6463 | 500 | 6554 | |
| G47 | 1000 | 9990 | 1 | 1 | 4977 | 6183 | 6412 | 51 | 87 | 6465 | 500 | 6551 | |
| G48 | 3000 | 6000 | 1 | 1 | 3012 | 5208 | 5453 | 23 | 52 | 5492 | 500 | 6000 | 6000 |
| G49 | 3000 | 6000 | 1 | 1 | 3005 | 4910 | 5489 | 25 | 57 | 5478 | 500 | 6000 | 6000 |
| G50 | 3000 | 6000 | 1 | 1 | 3007 | 4864 | 5300 | 26 | 59 | 5450 | 500 | 5880 | 5988 |
| G51 | 1000 | 5909 | 1 | 1 | 2963 | 3712 | 3729 | 23 | 29 | 3738 | 500 | 3790 | |
| G52 | 1000 | 5916 | 1 | 1 | 2953 | 3602 | 3708 | 23 | 29 | 3742 | 500 | 3790 | |
| G53 | 1000 | 5914 | 1 | 1 | 2959 | 3699 | 3707 | 23 | 28 | 3741 | 500 | 3799 | |
| G54 | 1000 | 5916 | 1 | 1 | 2960 | 3679 | 3716 | 23 | 28 | 3739 | 500 | 3788 | |