OTDM - Constrained Optimization - SVM

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Contents

Primal SVM Problem

We aim to solve the following optimization problem:

$$\min_{w,\gamma,s} \frac{1}{2} w^T w + \nu e^T s$$

Subject to:

$$Y(Aw + \gamma e) + s \geq e,$$
$$s \geq 0,$$

Where:

- **Decision Variables**:
$$(w, \gamma, s) \in \mathbb{R}^{n+1+m},$$
  - $w \in \mathbb{R}^n$: Weight vector for the hyperplane.
  - $\gamma \in \mathbb{R}$: Bias term.
  - $s \in \mathbb{R}^m$: Slack variables for handling misclassifications.
- **Constants**:
  - $\nu > 0$: Regularization parameter controlling the trade-off between margin size and misclassification penalty.
  - $A \in \mathbb{R}^{m \times n}$: Matrix where rows represent feature vectors of the data points.
  - $Y \in \mathbb{R}^{m \times m}$: Diagonal matrix of labels, where $Y_{ii} = y_i$, and $y_i \in \{-1, 1\}$.
  - $e \in \mathbb{R}^m$: Vector of ones ($e = [1, 1, \ldots, 1]^T$).

Dual

Dual SVM Formulation

We formulate the dual SVM model using explicit indices instead of matrix notation.

Objective Function

$$\max_{\lambda} \quad \sum_{i=1}^{m} \lambda_i - \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \lambda_i \lambda_j y_i y_j \left(\sum_{k=1}^{n} A_{ik} A_{jk} \right)$$

Subject to:

1. $$\sum_{i=1}^{m} \lambda_i y_i = 0$$
2. $$0 \leq \lambda_i \leq \nu, \quad \forall i = 1, \ldots, m$$

Where:

- λ_i: Dual variable for the i-th data point.
- y_i: Label of the i-th data point (± 1).
- A_{ik}: Feature k of the i-th data point.
- ν: Regularization parameter.

echo “Generating data using generator” cd /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/data_generator ./gensvmdat tes_raw.dat 1000 4624 ./gensvmdat trs_raw.dat 1000 7438042 ./gensvmdat tel_raw.dat 100000 4624 ./gensvmdat trl_raw.dat 100000 7438042

chmod +x process.sh ./process.sh tes_raw.dat tes.dat 1000 ./process.sh trs_raw.dat trs.dat 1000 ./process.sh tel_raw.dat tel.dat 100000 ./process.sh trl_raw.dat trl.dat 100000

Now we have generated training and test set, a small variant (100 data points) and a large one (100k data points).

cp teh.dat /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/primal/ cp trh.dat /home/julian/uni_folder/OTDM/OTD
cp teh.dat /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/dual/ cp trh.dat /home/julian/uni_folder/OTDM/OTDM

Copy the files to the target directories

echo "Copying files to target directories" cd /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/data_generator
cp tes.dat /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/primal/ cp trs.dat /home/julian/uni_folder/OTDM/OTDM
cp tel.dat /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/primal/ cp trl.dat /home/julian/uni_folder/OTDM/OTDM

cp tes.dat /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/dual/ cp trs.dat /home/julian/uni_folder/OTDM/OTDM_
cp tel.dat /home/julian/uni_folder/OTDM/OTDM_p2/OTDM/dual/ cp trl.dat /home/julian/uni_folder/OTDM/OTDM_

echo "Files copied successfully"

Train with small dataset:

Primal

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/primal
/Users/danilakokin/Downloads/ampl_macos64/ampl <<EOF
option solver cplex;
model primal.mod;
data trs.dat;

let nu := 1.0;

solve;
display n, gamma, w > mparams.dat;
quit;
EOF
```

Small dataset

```
## CPLEX 22.1.1.0: optimal solution; objective 406.3344042
## 11 separable QP barrier iterations
## No basis.
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/primal
chmod +x fix_params.sh
./fix_params.sh
```

```
## Processing mparams.dat into iparams.dat...
## Transformation complete. Output saved to iparams.dat.
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/primal
/Users/danilakokin/Downloads/ampl_macos64/ampl <<EOF
option solver cplex;
model eval.mod;
data tes.dat;
data iparams.dat;
display gamma, w;
display results;
display accuracy, precision, recall, f1_score;
quit;
EOF
```

```
## gamma = -5.4418
##
## w [*] :=
## 1  2.74357
## 2  2.45848
## 3  3.12064
## 4  2.67333
## ;
##
## results [*] :=
##    1 1    113 1    225 1    337 1    449 1    561 1    673 1    785 1    897 1
##    2 1    114 1    226 1    338 1    450 1    562 1    674 1    786 1    898 1
##    3 1    115 1    227 1    339 1    451 1    563 1    675 1    787 1    899 1
##    4 1    116 1    228 1    340 1    452 1    564 1    676 1    788 1    900 1
##    5 1    117 1    229 1    341 1    453 1    565 1    677 1    789 1    901 1
##    6 1    118 1    230 1    342 1    454 1    566 1    678 1    790 1    902 1
##    7 1    119 1    231 1    343 1    455 1    567 1    679 1    791 1    903 1
##    8 1    120 1    232 1    344 1    456 1    568 1    680 1    792 1    904 1
##    9 1    121 1    233 1    345 1    457 1    569 1    681 1    793 1    905 1
##   10 1    122 1    234 1    346 1    458 1    570 1    682 1    794 1    906 1
##   11 1    123 1    235 1    347 1    459 1    571 1    683 1    795 1    907 1
##   12 1    124 1    236 1    348 1    460 1    572 1    684 1    796 1    908 1
##   13 1    125 1    237 1    349 1    461 1    573 1    685 1    797 1    909 1
##   14 1    126 1    238 1    350 1    462 1    574 1    686 1    798 1    910 1
##   15 1    127 1    239 1    351 1    463 1    575 1    687 1    799 1    911 1
##   16 1    128 1    240 1    352 1    464 1    576 1    688 1    800 1    912 1
##   17 1    129 1    241 1    353 1    465 1    577 1    689 1    801 1    913 1
##   18 1    130 1    242 1    354 1    466 1    578 1    690 1    802 1    914 1
##   19 1    131 1    243 1    355 1    467 1    579 1    691 1    803 1    915 1
##   20 1    132 1    244 1    356 1    468 1    580 1    692 1    804 1    916 1
##   21 1    133 1    245 1    357 1    469 1    581 1    693 1    805 1    917 1
##   22 1    134 1    246 1    358 1    470 1    582 1    694 1    806 1    918 1
##   23 1    135 1    247 1    359 1    471 1    583 1    695 1    807 1    919 1
##   24 1    136 1    248 1    360 1    472 1    584 1    696 1    808 1    920 1
##   25 1    137 1    249 1    361 1    473 1    585 1    697 1    809 1    921 1
##   26 1    138 1    250 1    362 1    474 1    586 1    698 1    810 1    922 1
##   27 1    139 1    251 1    363 1    475 1    587 1    699 1    811 1    923 1
##   28 1    140 1    252 1    364 1    476 1    588 1    700 1    812 1    924 1
##   29 1    141 1    253 1    365 1    477 1    589 1    701 1    813 1    925 1
##   30 1    142 1    254 1    366 1    478 1    590 1    702 1    814 1    926 1
##   31 1    143 1    255 1    367 1    479 1    591 1    703 1    815 1    927 1
```

```
##   32 1    144 1    256 1    368 1    480 1    592 1    704 1    816 1    928 1
##   33 1    145 1    257 1    369 1    481 1    593 1    705 1    817 1    929 1
##   34 1    146 1    258 1    370 1    482 1    594 1    706 1    818 1    930 1
##   35 1    147 1    259 1    371 1    483 1    595 1    707 1    819 1    931 1
##   36 1    148 1    260 1    372 1    484 1    596 1    708 1    820 1    932 1
##   37 1    149 1    261 1    373 1    485 1    597 1    709 1    821 1    933 1
##   38 1    150 1    262 1    374 1    486 1    598 1    710 1    822 1    934 1
##   39 1    151 1    263 1    375 1    487 1    599 1    711 1    823 1    935 1
##   40 1    152 1    264 1    376 1    488 1    600 1    712 1    824 1    936 1
##   41 1    153 1    265 1    377 1    489 1    601 1    713 1    825 1    937 1
##   42 1    154 1    266 1    378 1    490 1    602 1    714 1    826 1    938 1
##   43 1    155 1    267 1    379 1    491 1    603 1    715 1    827 1    939 1
##   44 1    156 1    268 1    380 1    492 1    604 1    716 1    828 1    940 1
##   45 1    157 1    269 1    381 1    493 1    605 1    717 1    829 1    941 1
##   46 1    158 1    270 1    382 1    494 1    606 1    718 1    830 1    942 1
##   47 1    159 1    271 1    383 1    495 1    607 1    719 1    831 1    943 1
##   48 1    160 1    272 1    384 1    496 1    608 1    720 1    832 1    944 1
##   49 1    161 1    273 1    385 1    497 1    609 1    721 1    833 1    945 1
##   50 1    162 1    274 1    386 1    498 1    610 1    722 1    834 1    946 1
##   51 1    163 1    275 1    387 1    499 1    611 1    723 1    835 1    947 1
##   52 1    164 1    276 1    388 1    500 1    612 1    724 1    836 1    948 1
##   53 1    165 1    277 1    389 1    501 1    613 1    725 1    837 1    949 1
##   54 1    166 1    278 1    390 1    502 1    614 1    726 1    838 1    950 1
##   55 1    167 1    279 1    391 1    503 1    615 1    727 1    839 1    951 1
##   56 1    168 1    280 1    392 1    504 1    616 1    728 1    840 1    952 1
##   57 1    169 1    281 1    393 1    505 1    617 1    729 1    841 1    953 1
##   58 1    170 1    282 1    394 1    506 1    618 1    730 1    842 1    954 1
##   59 1    171 1    283 1    395 1    507 1    619 1    731 1    843 1    955 1
##   60 1    172 1    284 1    396 1    508 1    620 1    732 1    844 1    956 1
##   61 1    173 1    285 1    397 1    509 1    621 1    733 1    845 1    957 1
##   62 1    174 1    286 1    398 1    510 1    622 1    734 1    846 1    958 1
##   63 1    175 1    287 1    399 1    511 1    623 1    735 1    847 1    959 1
##   64 1    176 1    288 1    400 1    512 1    624 1    736 1    848 1    960 1
##   65 1    177 1    289 1    401 1    513 1    625 1    737 1    849 1    961 1
##   66 1    178 1    290 1    402 1    514 1    626 1    738 1    850 1    962 1
##   67 1    179 1    291 1    403 1    515 1    627 1    739 1    851 1    963 1
##   68 1    180 1    292 1    404 1    516 1    628 1    740 1    852 1    964 1
##   69 1    181 1    293 1    405 1    517 1    629 1    741 1    853 1    965 1
##   70 1    182 1    294 1    406 1    518 1    630 1    742 1    854 1    966 1
##   71 1    183 1    295 1    407 1    519 1    631 1    743 1    855 1    967 1
##   72 1    184 1    296 1    408 1    520 1    632 1    744 1    856 1    968 1
##   73 1    185 1    297 1    409 1    521 1    633 1    745 1    857 1    969 1
##   74 1    186 1    298 1    410 1    522 1    634 1    746 1    858 1    970 1
##   75 1    187 1    299 1    411 1    523 1    635 1    747 1    859 1    971 1
##   76 1    188 1    300 1    412 1    524 1    636 1    748 1    860 1    972 1
##   77 1    189 1    301 1    413 1    525 1    637 1    749 1    861 1    973 1
##   78 1    190 1    302 1    414 1    526 1    638 1    750 1    862 1    974 1
##   79 1    191 1    303 1    415 1    527 1    639 1    751 1    863 1    975 1
##   80 1    192 1    304 1    416 1    528 1    640 1    752 1    864 1    976 1
##   81 1    193 1    305 1    417 1    529 1    641 1    753 1    865 1    977 1
##   82 1    194 1    306 1    418 1    530 1    642 1    754 1    866 1    978 1
##   83 1    195 1    307 1    419 1    531 1    643 1    755 1    867 1    979 1
##   84 1    196 1    308 1    420 1    532 1    644 1    756 1    868 1    980 1
##   85 1    197 1    309 1    421 1    533 1    645 1    757 1    869 1    981 1
```

```
##   86 1    198 1    310 1    422 1    534 1    646 1    758 1    870 1    982 1
##   87 1    199 1    311 1    423 1    535 1    647 1    759 1    871 1    983 1
##   88 1    200 1    312 1    424 1    536 1    648 1    760 1    872 1    984 1
##   89 1    201 1    313 1    425 1    537 1    649 1    761 1    873 1    985 1
##   90 1    202 1    314 1    426 1    538 1    650 1    762 1    874 1    986 1
##   91 1    203 1    315 1    427 1    539 1    651 1    763 1    875 1    987 1
##   92 1    204 1    316 1    428 1    540 1    652 1    764 1    876 1    988 1
##   93 1    205 1    317 1    429 1    541 1    653 1    765 1    877 1    989 1
##   94 1    206 1    318 1    430 1    542 1    654 1    766 1    878 1    990 1
##   95 1    207 1    319 1    431 1    543 1    655 1    767 1    879 1    991 1
##   96 1    208 1    320 1    432 1    544 1    656 1    768 1    880 1    992 1
##   97 1    209 1    321 1    433 1    545 1    657 1    769 1    881 1    993 1
##   98 1    210 1    322 1    434 1    546 1    658 1    770 1    882 1    994 1
##   99 1    211 1    323 1    435 1    547 1    659 1    771 1    883 1    995 1
##  100 1    212 1    324 1    436 1    548 1    660 1    772 1    884 1    996 1
##  101 1    213 1    325 1    437 1    549 1    661 1    773 1    885 1    997 1
##  102 1    214 1    326 1    438 1    550 1    662 1    774 1    886 1    998 1
##  103 1    215 1    327 1    439 1    551 1    663 1    775 1    887 1    999 1
##  104 1    216 1    328 1    440 1    552 1    664 1    776 1    888 1   1000 1
##  105 1    217 1    329 1    441 1    553 1    665 1    777 1    889 1
##  106 1    218 1    330 1    442 1    554 1    666 1    778 1    890 1
##  107 1    219 1    331 1    443 1    555 1    667 1    779 1    891 1
##  108 1    220 1    332 1    444 1    556 1    668 1    780 1    892 1
##  109 1    221 1    333 1    445 1    557 1    669 1    781 1    893 1
##  110 1    222 1    334 1    446 1    558 1    670 1    782 1    894 1
##  111 1    223 1    335 1    447 1    559 1    671 1    783 1    895 1
##  112 1    224 1    336 1    448 1    560 1    672 1    784 1    896 1
## ;
##
## accuracy = 0.501
## precision = 0.501
## recall = 1
## f1_score = 0.667555
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/primal
/Users/danilakokin/Downloads/ampl_macos64/ampl <<EOF
option solver cplex;
model primal.mod;
data trl.dat;

let nu := 1.0;

solve;
display n, gamma, w > mparams.dat;
quit;
EOF
```

Large dataset

```
## CPLEX 22.1.1.0: optimal solution; objective 29690.02995
## 15 separable QP barrier iterations
## No basis.
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/primal
chmod +x fix_params.sh
./fix_params.sh
```

```
## Processing mparams.dat into iparams.dat...
## Transformation complete. Output saved to iparams.dat.
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/primal
/Users/danilakokin/Downloads/ampl_macos64/ampl <<EOF
option solver cplex;
model eval.mod;
data tel.dat;
data iparams.dat;
display gamma, w;
display accuracy, precision, recall, f1_score;
quit;
EOF
```

```
## gamma = -10.0039
##
## w [*] :=
## 1  4.98053
## 2  5.01125
## 3  5.03267
## 4  4.99326
## ;
##
## accuracy = 0.50015
## precision = 0.50015
## recall = 1
## f1_score = 0.6668
```

Dual

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/dual
/Users/danilakokin/Downloads/ampl_macos64/ampl <<EOF
option solver cplex;
model dual.mod;
data trs.dat;

let nu := 1.0;

solve;
display n, gamma, w > mparams.dat;
quit;
EOF
```

Small dataset

```
## CPLEX 22.1.1.0: optimal solution; objective 320.511461
## 21 QP barrier iterations
## No basis.
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/dual
chmod +x fix_params.sh
./fix_params.sh
```

```
## Processing mparams.dat into iparams.dat...
## Transformation complete. Output saved to iparams.dat.
```

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/dual
/Users/danilakokin/Downloads/ampl_macos64/ampl <<EOF
model eval.mod;
data tes.dat;
data iparams.dat;
display gamma, w;
display results;
display accuracy, precision, recall, f1_score;
quit;
EOF
```

```
## gamma = -9.94306
##
## w [*] :=
## 1  3.98852
## 2  3.79188
## 3  4.36573
## 4  4.04303
## ;
##
## results [*] :=
##    1 1    113 1    225 1    337 1    449 1    561 1    673 1    785 1    897 1
##    2 1    114 1    226 1    338 1    450 1    562 1    674 1    786 1    898 1
##    3 1    115 1    227 1    339 1    451 1    563 1    675 1    787 1    899 1
##    4 1    116 1    228 1    340 1    452 1    564 1    676 1    788 1    900 1
##    5 1    117 1    229 1    341 1    453 1    565 1    677 1    789 1    901 1
##    6 1    118 1    230 1    342 1    454 1    566 1    678 1    790 1    902 1
##    7 1    119 1    231 1    343 1    455 1    567 1    679 1    791 1    903 1
##    8 1    120 1    232 1    344 1    456 1    568 1    680 1    792 1    904 1
##    9 1    121 1    233 1    345 1    457 1    569 1    681 1    793 1    905 1
##   10 1    122 1    234 1    346 1    458 1    570 1    682 1    794 1    906 1
##   11 1    123 1    235 1    347 1    459 1    571 1    683 1    795 1    907 1
##   12 1    124 1    236 1    348 1    460 1    572 1    684 1    796 1    908 1
##   13 1    125 1    237 1    349 1    461 1    573 1    685 1    797 1    909 1
##   14 1    126 1    238 1    350 1    462 1    574 1    686 1    798 1    910 1
##   15 1    127 1    239 1    351 1    463 1    575 1    687 1    799 1    911 1
##   16 1    128 1    240 1    352 1    464 1    576 1    688 1    800 1    912 1
##   17 1    129 1    241 1    353 1    465 1    577 1    689 1    801 1    913 1
##   18 1    130 1    242 1    354 1    466 1    578 1    690 1    802 1    914 1
##   19 1    131 1    243 1    355 1    467 1    579 1    691 1    803 1    915 1
##   20 1    132 1    244 1    356 1    468 1    580 1    692 1    804 1    916 1
##   21 1    133 1    245 1    357 1    469 1    581 1    693 1    805 1    917 1
```

```
##   22 1   134 1   246 1   358 1   470 1   582 1   694 1   806 1   918 1
##   23 1   135 1   247 1   359 1   471 1   583 1   695 1   807 1   919 1
##   24 1   136 1   248 1   360 1   472 1   584 1   696 1   808 1   920 1
##   25 1   137 1   249 1   361 1   473 1   585 1   697 1   809 1   921 1
##   26 1   138 1   250 1   362 1   474 1   586 1   698 1   810 1   922 1
##   27 1   139 1   251 1   363 1   475 1   587 1   699 1   811 1   923 1
##   28 1   140 1   252 1   364 1   476 1   588 1   700 1   812 1   924 1
##   29 1   141 1   253 1   365 1   477 1   589 1   701 1   813 1   925 1
##   30 1   142 1   254 1   366 1   478 1   590 1   702 1   814 1   926 1
##   31 1   143 1   255 1   367 1   479 1   591 1   703 1   815 1   927 1
##   32 1   144 1   256 1   368 1   480 1   592 1   704 1   816 1   928 1
##   33 1   145 1   257 1   369 1   481 1   593 1   705 1   817 1   929 1
##   34 1   146 1   258 1   370 1   482 1   594 1   706 1   818 1   930 1
##   35 1   147 1   259 1   371 1   483 1   595 1   707 1   819 1   931 1
##   36 1   148 1   260 1   372 1   484 1   596 1   708 1   820 1   932 1
##   37 1   149 1   261 1   373 1   485 1   597 1   709 1   821 1   933 1
##   38 1   150 1   262 1   374 1   486 1   598 1   710 1   822 1   934 1
##   39 1   151 1   263 1   375 1   487 1   599 1   711 1   823 1   935 1
##   40 1   152 1   264 1   376 1   488 1   600 1   712 1   824 1   936 1
##   41 1   153 1   265 1   377 1   489 1   601 1   713 1   825 1   937 1
##   42 1   154 1   266 1   378 1   490 1   602 1   714 1   826 1   938 1
##   43 1   155 1   267 1   379 1   491 1   603 1   715 1   827 1   939 1
##   44 1   156 1   268 1   380 1   492 1   604 1   716 1   828 1   940 1
##   45 1   157 1   269 1   381 1   493 1   605 1   717 1   829 1   941 1
##   46 1   158 1   270 1   382 1   494 1   606 1   718 1   830 1   942 1
##   47 1   159 1   271 1   383 1   495 1   607 1   719 1   831 1   943 1
##   48 1   160 1   272 1   384 1   496 1   608 1   720 1   832 1   944 1
##   49 1   161 1   273 1   385 1   497 1   609 1   721 1   833 1   945 1
##   50 1   162 1   274 1   386 1   498 1   610 1   722 1   834 1   946 1
##   51 1   163 1   275 1   387 1   499 1   611 1   723 1   835 1   947 1
##   52 1   164 1   276 1   388 1   500 1   612 1   724 1   836 1   948 1
##   53 1   165 1   277 1   389 1   501 1   613 1   725 1   837 1   949 1
##   54 1   166 1   278 1   390 1   502 1   614 1   726 1   838 1   950 1
##   55 1   167 1   279 1   391 1   503 1   615 1   727 1   839 1   951 1
##   56 1   168 1   280 1   392 1   504 1   616 1   728 1   840 1   952 1
##   57 1   169 1   281 1   393 1   505 1   617 1   729 1   841 1   953 1
##   58 1   170 1   282 1   394 1   506 1   618 1   730 1   842 1   954 1
##   59 1   171 1   283 1   395 1   507 1   619 1   731 1   843 1   955 1
##   60 1   172 1   284 1   396 1   508 1   620 1   732 1   844 1   956 1
##   61 1   173 1   285 1   397 1   509 1   621 1   733 1   845 1   957 1
##   62 1   174 1   286 1   398 1   510 1   622 1   734 1   846 1   958 1
##   63 1   175 1   287 1   399 1   511 1   623 1   735 1   847 1   959 1
##   64 1   176 1   288 1   400 1   512 1   624 1   736 1   848 1   960 1
##   65 1   177 1   289 1   401 1   513 1   625 1   737 1   849 1   961 1
##   66 1   178 1   290 1   402 1   514 1   626 1   738 1   850 1   962 1
##   67 1   179 1   291 1   403 1   515 1   627 1   739 1   851 1   963 1
##   68 1   180 1   292 1   404 1   516 1   628 1   740 1   852 1   964 1
##   69 1   181 1   293 1   405 1   517 1   629 1   741 1   853 1   965 1
##   70 1   182 1   294 1   406 1   518 1   630 1   742 1   854 1   966 1
##   71 1   183 1   295 1   407 1   519 1   631 1   743 1   855 1   967 1
##   72 1   184 1   296 1   408 1   520 1   632 1   744 1   856 1   968 1
##   73 1   185 1   297 1   409 1   521 1   633 1   745 1   857 1   969 1
##   74 1   186 1   298 1   410 1   522 1   634 1   746 1   858 1   970 1
##   75 1   187 1   299 1   411 1   523 1   635 1   747 1   859 1   971 1
```

```
##   76 1    188 1    300 1    412 1    524 1    636 1    748 1    860 1    972 1
##   77 1    189 1    301 1    413 1    525 1    637 1    749 1    861 1    973 1
##   78 1    190 1    302 1    414 1    526 1    638 1    750 1    862 1    974 1
##   79 1    191 1    303 1    415 1    527 1    639 1    751 1    863 1    975 1
##   80 1    192 1    304 1    416 1    528 1    640 1    752 1    864 1    976 1
##   81 1    193 1    305 1    417 1    529 1    641 1    753 1    865 1    977 1
##   82 1    194 1    306 1    418 1    530 1    642 1    754 1    866 1    978 1
##   83 1    195 1    307 1    419 1    531 1    643 1    755 1    867 1    979 1
##   84 1    196 1    308 1    420 1    532 1    644 1    756 1    868 1    980 1
##   85 1    197 1    309 1    421 1    533 1    645 1    757 1    869 1    981 1
##   86 1    198 1    310 1    422 1    534 1    646 1    758 1    870 1    982 1
##   87 1    199 1    311 1    423 1    535 1    647 1    759 1    871 1    983 1
##   88 1    200 1    312 1    424 1    536 1    648 1    760 1    872 1    984 1
##   89 1    201 1    313 1    425 1    537 1    649 1    761 1    873 1    985 1
##   90 1    202 1    314 1    426 1    538 1    650 1    762 1    874 1    986 1
##   91 1    203 1    315 1    427 1    539 1    651 1    763 1    875 1    987 1
##   92 1    204 1    316 1    428 1    540 1    652 1    764 1    876 1    988 1
##   93 1    205 1    317 1    429 1    541 1    653 1    765 1    877 1    989 1
##   94 1    206 1    318 1    430 1    542 1    654 1    766 1    878 1    990 1
##   95 1    207 1    319 1    431 1    543 1    655 1    767 1    879 1    991 1
##   96 1    208 1    320 1    432 1    544 1    656 1    768 1    880 1    992 1
##   97 1    209 1    321 1    433 1    545 1    657 1    769 1    881 1    993 1
##   98 1    210 1    322 1    434 1    546 1    658 1    770 1    882 1    994 1
##   99 1    211 1    323 1    435 1    547 1    659 1    771 1    883 1    995 1
##  100 1    212 1    324 1    436 1    548 1    660 1    772 1    884 1    996 1
##  101 1    213 1    325 1    437 1    549 1    661 1    773 1    885 1    997 1
##  102 1    214 1    326 1    438 1    550 1    662 1    774 1    886 1    998 1
##  103 1    215 1    327 1    439 1    551 1    663 1    775 1    887 1    999 1
##  104 1    216 1    328 1    440 1    552 1    664 1    776 1    888 1   1000 1
##  105 1    217 1    329 1    441 1    553 1    665 1    777 1    889 1
##  106 1    218 1    330 1    442 1    554 1    666 1    778 1    890 1
##  107 1    219 1    331 1    443 1    555 1    667 1    779 1    891 1
##  108 1    220 1    332 1    444 1    556 1    668 1    780 1    892 1
##  109 1    221 1    333 1    445 1    557 1    669 1    781 1    893 1
##  110 1    222 1    334 1    446 1    558 1    670 1    782 1    894 1
##  111 1    223 1    335 1    447 1    559 1    671 1    783 1    895 1
##  112 1    224 1    336 1    448 1    560 1    672 1    784 1    896 1
## ;
##
## accuracy = 0.501
## precision = 0.501
## recall = 1
## f1_score = 0.667555
```

Large dataset cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/dual /Users/danilakokin/Downloads/ampl_macos64/ampl «EOF option solver cplex; model dual.mod; data tel.dat;

let nu := 1.0; solve;

display n, gamma, w > mparams.dat; quit; EOF

cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/dual chmod +x fix_params.sh ./fix_params.sh

```
cd /Users/danilakokin/Desktop/UPC/Semester3/OTDM/OTDM_Project_2/dual /Users/danilakokin/Downloads/ampl_m
«EOF model eval.mod; data tel.dat; data iparams.dat; display results; display accuracy, precision, recall,
f1_score; quit; EOF
```