Appendix
Numerical Data for Illustrative Examples

A.1 Hyperplane Arrangements in $\mathbb{R}^2$ with 4 Hyperplanes

The hyperplane arrangement used in the illustrative example of Sect. 2.1 and the numerical observations from Sect. 2.3.2 is given by[1]:

$$H = \begin{bmatrix} 0.673 & 0.740 \\ 0.857 & -0.514 \\ -0.476 & 0.879 \\ 0.000 & 1.000 \end{bmatrix}, \quad k = \begin{bmatrix} 0.336 \\ 0.000 \\ 0.183 \\ 2.000 \end{bmatrix}. \tag{A.1}$$

The perturbed hyperplane arrangement described in the illustrative example of Sect. 2.1 and also analyzed in the illustrative example for region counting in Sect. 2.1.1 is given by:

$$H = \begin{bmatrix} 0.673 & 0.740 \\ 0.857 & -0.514 \\ 0.600 & -0.800 \\ 0.000 & 1.000 \end{bmatrix}, \quad k = \begin{bmatrix} 0.336 \\ 0.000 \\ 1.000 \\ 2.000 \end{bmatrix}. \tag{A.2}$$

A.2 Hyperplane Arrangements in $\mathbb{R}^3$ with 4 Hyperplanes

The parametrized hyperplane arrangement lifted in $\mathbb{R}^3$ as in (2.10) and presented in the illustrative example for hyperplane parametrization of Sect. 2.1.2 is given by the following numerical data:

[1]Matrices H and k store row-wise the elements defining the current hyperplane arrangement as in (2.1).

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$$H = \begin{bmatrix} 0.2184 & -0.3944 & -0.4092 \\ 0.4686 & 0.1110 & -0.2335 \\ 0.0313 & 0.2788 & -0.3463 \\ -0.1749 & -0.0765 & -0.2190 \end{bmatrix}, \quad k = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}. \tag{A.3}$$

A.3 Hyperplane Arrangements in $\mathbb{R}^2$ with 3 Hyperplanes

The following hyperplane arrangement is used for the numerical observations provided in Sects. 2.3.2 and 3.6:

$$H = \begin{bmatrix} -0.0250 & -0.9997 \\ -0.6190 & 0.7854 \\ 0.9983 & -0.0583 \end{bmatrix}, \quad k = \begin{bmatrix} 4.7798 \\ 2.2037 \\ 5.9584 \end{bmatrix}. \tag{A.4}$$

The collection of forbidden tuples (see the description provided in (2.19)) of the above hyperplane arrangement used in the numerical consideration of Sects. 2.3.2 and 3.6 is: $\Sigma^{\bullet,1} = \{(+++)\}$, $\Sigma^{\bullet,2} = \{(+-+), (+--)\}$.

A.4 Hyperplane Arrangement in $\mathbb{R}^2$ with 8 Hyperplanes

The following hyperplane arrangement is used first in the illustrative example of non-convex regions in Sect. 2.3 and continued throughout the book in the illustrative example of merging procedures Sect. 2.3.1, numerical considerations Sect. 2.3.2, illustrative example for tuple allocation Sect. 3.2, illustrative example for mixed-integer formulations for the complement of a union of convex sets Sect. 3.3, illustrative example for mixed-integer formulations for the union of feasible cells Sect. 3.4, illustrative example for mixed-integer formulations for the feasible region characterized directly through the arrangement Sect. 3.5 and the numerical considerations in Sect. 3.6:

$$H = \begin{bmatrix} 0.7061 & -0.7081 \\ 0.0532 & -0.9986 \\ -0.9584 & -0.2855 \\ 0.1784 & 0.9840 \\ 1.0000 & 0 \\ 0.7577 & 0.6526 \\ -0.3427 & 0.9394 \\ 0.9172 & 0.3984 \end{bmatrix}, \quad k = \begin{bmatrix} 1.1403 \\ 2.9327 \\ 8.6224 \\ 1.5864 \\ 7.7650 \\ 8.6885 \\ 4.4814 \\ 3.9327 \end{bmatrix}. \tag{A.5}$$

Furthermore, the associated collection of forbidden tuples (see the description provided in (2.19)) of the above hyperplane arrangement used in the numerical consideration of Sects. 2.3.2 and 3.6 is:
$\Sigma^{\bullet,1} = \{(+-+++++++), (+++-+++-), (-++-+++-)\}$.
$\Sigma^{\bullet,2} = \{(-++++++++), (+-+++++++), (+++-+++-), (-++-+++-), (-++-+++++)\}$.

A.5 Hyperplane Arrangement in $\mathbb{R}^2$ with 10 Hyperplanes

The following hyperplane arrangement is used for the numerical observations provided in Sects. 2.3.2 and 3.6:

$$H = \begin{bmatrix} -0.0134 & -0.9999 \\ -0.7822 & -0.6231 \\ -0.9999 & 0.0173 \\ -0.6312 & -0.7756 \\ 0.9844 & 0.1760 \\ 0.8663 & -0.4995 \\ -0.1076 & 0.9942 \\ -0.8091 & 0.5876 \\ 0.1496 & 0.9887 \\ -0.8177 & 0.5756 \end{bmatrix}, \quad k = \begin{bmatrix} 9.8619 \\ 10.0495 \\ 9.2534 \\ 0.6254 \\ 7.9396 \\ 7.2362 \\ 5.3507 \\ 2.9736 \\ 8.6598 \\ 7.3975 \end{bmatrix}. \tag{A.6}$$

The associated collection of forbidden tuples of the hyperplane arrangement in (A.6) is given by:
$\Sigma^{\bullet,1} = \{(+-+-++++++), (+-+-+++-++), (++++++--++), (+++++-++++)\}$.
$\Sigma^{\bullet,2} = \{(++--+++-++), (+---+++-++), (++--+++-+-), (+++++-++++), (++++++++++), (++++++-+++), (++++--++-+)\}$.

A.6 Hyperplane Arrangement in $\mathbb{R}^2$ with 15 Hyperplanes

The hyperplane arrangement with 15 hyperplanes used for the numerical observations in Sects. 2.3.2 and 3.6 is given by:

$$H = \begin{bmatrix} 0.2810 & -0.9597 \\ -0.9994 & 0.0332 \\ -0.2261 & -0.9741 \\ -0.8722 & 0.4892 \\ -0.9016 & -0.4325 \\ 0.5457 & -0.8380 \\ 0.9818 & -0.1900 \\ 0.4778 & 0.8785 \\ -0.4713 & 0.8820 \\ 0.8572 & 0.5150 \\ -0.4854 & -0.8743 \\ 0.0298 & -0.9996 \\ 0.9940 & -0.1091 \\ -0.1431 & -0.9897 \\ 0.6968 & -0.7173 \end{bmatrix}, \quad k = \begin{bmatrix} 3.6436 \\ 3.5455 \\ 0.1421 \\ 7.1289 \\ 9.1531 \\ 1.0230 \\ 8.1203 \\ 11.8156 \\ 4.9609 \\ 6.1583 \\ 5.4883 \\ 9.1173 \\ 9.6930 \\ 2.8675 \\ 6.5968 \end{bmatrix}. \tag{A.7}$$

The associated collection of forbidden tuples of the above hyperplane arrangement is:

$\Sigma^{\bullet,1}$ = {(+−−+++++++−++−+), (+−−+++++++−++++), (+−−++++++++++++), (+−−++++++++++−+), (+−−++−++++−++−+), (+−−++−+++++++−+), (−+−++−+++++++−−), (−+−++−−++++++−−), (+++++++++−+++++)}.

$\Sigma^{\bullet,2}$ = {(+−−+++++++−++−+), (+−−++++++++++−+), (+−−++++++++++++), (+−−+++++++−++++), (+−−++−+++++++−+), (+−−++−++++−++−+), (−+−++−+++++++−−), (−+−++−−++++++−−), (−+−++−++++−++−−), (−+−++−++++++++−), (−+−++−−+++++++−), (−++++−−++−++++−), (−+−++−−++−++++−), (−++++−−+++++++−), (−++++−++++++++−), (++++++++−++++++), (+++−++++−++++++), (+++−+++−−++++++), (+++++−−++−++−++), (+++++−−−+−++−++), (++++++−++−++−++), (++++++−++−+++++), (+++++++++−+++++)}.

A.7 Hyperplane Arrangement in $\mathbb{R}^2$ with 20 Hyperplanes

The hyperplane arrangement with 20 hyperplanes used for the numerical observations in Sects. 2.3.2 and 3.6 is:

$$
H = \begin{bmatrix} 0.6788 & 0.7344 \\ -0.3861 & -0.9225 \\ 0.0890 & -0.9960 \\ 0.2177 & 0.9760 \\ -0.4780 & 0.8784 \\ 0.9988 & -0.0480 \\ 0.5009 & -0.8655 \\ 0.8920 & 0.4520 \\ -0.8996 & 0.4368 \\ 0.8263 & -0.5632 \\ -0.5066 & 0.8622 \\ -0.3709 & -0.9287 \\ 0.7230 & 0.6909 \\ -0.9945 & -0.1046 \\ 0.1375 & -0.9905 \\ -0.9825 & 0.1865 \\ 0.3033 & 0.9529 \\ 0.8982 & -0.4396 \\ 0.9672 & 0.2540 \\ 0.2379 & 0.9713 \end{bmatrix}, \quad k = \begin{bmatrix} 0.1465 \\ 4.4491 \\ 0.6655 \\ 2.0252 \\ 7.1799 \\ 0.5265 \\ 7.4761 \\ 6.2232 \\ 1.4269 \\ 0.0590 \\ 4.5748 \\ 1.8940 \\ 2.6388 \\ 3.3731 \\ 7.5032 \\ 7.8669 \\ 6.4685 \\ 6.2249 \\ 0.3415 \\ 8.5629 \end{bmatrix}. \tag{A.8}
$$

The collection of forbidden tuples of the hyperplane arrangement in (A.8) is:

$\Sigma^{\bullet,1}$ = {(++++++++−++−+−++++++), (++−+++++−++−+−++++++), (++++++++−++++−++++++), (−++−+−+++−++−+++++−+), (−++−+−+−+−++−+++++−+), (−++−+−+++−++++++++−+), (−++−−+++−+−+−+++−+++), (−++−−+++−+−+−+++++++), (−++−−+++−+−+++++++++)}.

$\Sigma^{\bullet,2}$ = {(+−−+++++−++−+−++++++), (+−−++++++++−+−++++++), (+−−++++++−+−+−++++++), (−++−+−+++−++−+++++−+), (−++−+−++++++−+++++−+), (−++−+−+−+−++++++−+++−+−+), (−++−++++++++−+++++−+), (−++−−+++−+−++−++++++), (−++−−+++−+−++−++−+++), (−++−++++−+−++−++++++), (++−++−−++−+−+++++−−+), (−+−++−−++−+−+++++−−+), (−+−++−+++−+−+++++−−+), (++−++−+++−+−+++++−−+)}.

A.8 Hyperplane Arrangement in $\mathbb{R}^2$ with 25 Hyperplanes

The hyperplane arrangement with 25 hyperplanes used for the numerical observations in Sects. 2.3.2 and 3.6 is the following:

$$H = \begin{bmatrix} -0.0369 & -0.9993 \\ -0.8121 & -0.5835 \\ -0.8955 & 0.4451 \\ -0.3497 & -0.9369 \\ 0.6692 & -0.7431 \\ 0.9721 & 0.2347 \\ 0.7124 & -0.7018 \\ -0.6766 & 0.7363 \\ -0.0134 & 0.9999 \\ -0.9949 & -0.1012 \\ 0.8083 & -0.5887 \\ -0.0244 & 0.9997 \\ 0.9941 & -0.1085 \\ 0.5977 & -0.8017 \\ 0.1435 & 0.9896 \\ 0.9485 & 0.3167 \\ -0.4223 & -0.9065 \\ -0.9800 & 0.1989 \\ -0.5730 & -0.8195 \\ -0.8655 & 0.5009 \\ -0.8093 & -0.5874 \\ 0.8359 & -0.5489 \\ 0.9626 & 0.2709 \\ 0.3205 & -0.9472 \\ -0.9975 & -0.0702 \end{bmatrix}, \quad k = \begin{bmatrix} 10.1488 \\ 9.8786 \\ 4.3678 \\ 6.2746 \\ 12.9809 \\ 7.5973 \\ 9.8859 \\ 10.6347 \\ 9.7468 \\ 8.5397 \\ 2.2924 \\ 9.4343 \\ 6.4009 \\ 3.2242 \\ 3.9199 \\ 4.9772 \\ 4.8237 \\ 4.7993 \\ 1.7939 \\ 7.3355 \\ 2.5228 \\ 5.4023 \\ 1.8647 \\ 1.3794 \\ 0.0316 \end{bmatrix}. \qquad \text{(A.9)}$$

The collection of forbidden tuples of the above hyperplane arrangement is given by:

$\Sigma^{\bullet,1}$ = {(++−++++−+++−++−++−+−++++−), (++−++++−++++++−++−+−++++−), (++−++++−++++++−++−+−−+++−), (++−++++++++++++++−−+−+++−), (+++++++++++++++++−−+−+++−), (++−++++++−+++++++−−+−+++−), (+−+−++++++++++++−−−+−++−−), (+−+−+++++−++++++−−−+−++−−), (+−+−+++++++++−++−−−+−++−−), (+−+−+++++++++−++−+−+−++−−), (+−+−++++++++++++−+−+−++−−), (+++++++++++++++++++++++−+), (++++++++++−++++++++++++−+), (++++++++++++++++++−++++−+), (++++++++++−+++++++−++++−+), (++++++++++−++−++++−++++−+), (++++++++++−++−+++++++++−+), (++++++++++−++−++−+−++++−+), (++++++−+++−+−−++++−++−−−+), (++++++−+++−+−−+++++++−−−+), (++++++−+++−+−−++−+−++−−−+), (++++++−+++−+−−+−−+−++−−−+), (++++++−+++−+−−+−++−++−−−+), (++++++−+++−+−−+−+++++−−−+), (+++++++++++++++−++++++−++), (++++

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+++++++−++), (+++++−++++−+−++−++++++−++), (++
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+−+++++++−−+), (+++++−++++++−+−−+++++++−++)}.
$\Sigma^{\bullet,2}$ = {(++−++++−+++−++−++−+−+++++−), (++−+++++−
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−+++++−−++−++−+++++++++−++), (+−−++++++++−++++
++−−−−−++++−), (+−−+++++++−+++++++++−−−−+++−)}.

A.9 Hyperplane Arrangement in $\mathbb{R}^2$ with 30 Hyperplanes

The hyperplane arrangement with 30 hyperplanes used for the numerical observations in Sects. 2.3.2 and 3.6 is given by:

$$H = \begin{bmatrix} -0.1069 & -0.9943 \\ 0.6363 & -0.7714 \\ -0.8853 & -0.4651 \\ 0.0791 & -0.9969 \\ -0.9957 & 0.0931 \\ 0.1035 & 0.9946 \\ -0.8545 & 0.5195 \\ -0.8676 & -0.4972 \\ -0.1081 & 0.9941 \\ -0.9871 & -0.1601 \\ 0.7955 & 0.6060 \\ -0.0403 & 0.9992 \\ 0.8971 & -0.4418 \\ 0.0675 & 0.9977 \\ -0.6650 & 0.7468 \\ 0.0295 & -0.9996 \\ 0.9414 & -0.3372 \\ 0.9547 & 0.2974 \\ 0.4854 & -0.8743 \\ 0.8924 & 0.4512 \\ -0.0528 & -0.9986 \\ 0.7739 & -0.6333 \\ 0.9537 & 0.3006 \\ 0.2968 & -0.9549 \\ 0.9570 & 0.2901 \\ 0.0816 & -0.9967 \\ 0.9487 & -0.3163 \\ 0.3705 & 0.9288 \\ -0.6812 & 0.7321 \\ -0.8789 & -0.4771 \end{bmatrix}, \quad k = \begin{bmatrix} 10.0882 \\ 2.7396 \\ 8.2881 \\ 4.8767 \\ 8.9032 \\ 4.2338 \\ 7.1722 \\ 0.2417 \\ 10.0049 \\ 7.3457 \\ 6.1603 \\ 5.0181 \\ 3.6768 \\ 9.5919 \\ 3.5357 \\ 3.3916 \\ 9.4935 \\ 9.2727 \\ 2.7050 \\ 4.7929 \\ 9.1356 \\ 11.2074 \\ 5.1821 \\ 7.5297 \\ 0.5360 \\ 1.7437 \\ 2.1479 \\ 2.3465 \\ 2.3203 \\ 1.8710 \end{bmatrix}. \qquad \text{(A.10)}$$

The associated collection of forbidden tuples of the above hyperplane arrangement is the following:
$\Sigma^{\bullet,1} = \{(++--+++-+-+++++-+++++++++-+++-), (++--$
$+++-+-+++++-++-++++++-+++-), (++--+++-++++++$
$+-++-++++++-+++-), (++--+++-+++++++-++++++++$
$+-+++-), (++--+++-+-+++++-++-+-++++-+++-), (+-$
$+-+++-++++-++-++-++++----+++), (+-+-++++++++$
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$\Sigma^{\bullet,2}$ = {(++−−+++−+−+++++−++++++++++−+++−), (++−−++
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++++++++++−++−−), (++−++++−+−++++−+++++++
++++++−−), (++−++++−+−++++−++++++++++−++−−)}.

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Tamer Başar is with the University of Illinois at Urbana-Champaign, where he holds the academic positions of Swanlund Endowed Chair, Center for Advanced Study Professor of Electrical and Computer Engineering, Research Professor at the Coordinated Science Laboratory, and Research Professor at the Information Trust Institute. He received the B.S.E.E. degree from Robert College, Istanbul, and the M.S., M.Phil, and Ph.D. degrees from Yale University. He has published extensively in systems, control, communications, and dynamic games, and has current research interests that address fundamental issues in these areas along with applications such as formation in adversarial environments, network security, resilience in cyber-physical systems, and pricing in networks.

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- theory and control of nonlinear systems, in particular hybrid (logic/dynamic, symbol/signal) systems.

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