127 MT2 AX & b EIRM defines a region which is the Called to control of the Mills of and the intersection of m half-space. Which Start & Starts at Start X It is a polyhedron. I will will in it SA SA If bounded is it is a polytople. (11 1.18 ALCHX - 11X) · Probability simplex: 111 1/11 P= {x + | x n : x n o , Z | x i = | 3 (polytope) = co {e(1) . e(n) } n vertices By Andrew Contraction of the state of the state of · 1- norm ball

D = { x < | x | 1 | | | | }  $\frac{1}{2} \frac{1}{2} \frac{1}$ = { x + 1 RM : Z 1 x i 1 \ 1 } = { x < | R" · max | sT x < | } (polytope) I. IP Model: px = min ctx+ St. Acqx = beg Axsb introduction and it may set it is at the attention of the 5: 12" -> 12, is polyhedral if its opigraph is polyhedron A Comment of the Contract of t ine. epit= Eroxit) Elkatt - fix) = } in production of the state of the state of the = {(X,t)) c| Rn+1: c[x] =d 3 for some CEIRMINH, deIRM · f(x) = max ait x +bi is poly hedral epifizitivelenti: aitxabist, victin]} · f(x)=(Hx1) = max max (x1) - xi) epif=f(x10) eppn+1: ]welk?. It wat, aix+bis suit

· If fiz polyhedral, there: · Sewond -order cone (osoc): Kn= Elxity, XEIR, telking 11 x1/2 = t } 13 coust on IP: Rotated second-order cone !: " min fort st: ANSby (Not) the fire of 11 Kin = { (x,y,2), x=1kh, y1,2 E1k + x x = 242, 420, 270} W:= [1/2 W-2)] + = W+2)/52 10. · min MAX-bitto 29/11/2 1/2/2/3 mht stillAx-blost (xiy, 8) & Kn ( ) ( wit) & Kn+1 611 11 11 sit: ai X-bist, aitx-bizz-t 2 y, t) & km, y, t are affine for of x · min | IAX-b11; · SOCP: min otxi is in in the second S.t. S. MAIN +bilb & CiTX+di <>> min \$1tup st.: aitx-bi≤ui · Q top P -> SOCP: 10 /2 1/1/1 1/1/1 1/1/1 1/1/1 minixTex+aTx Jumin aTx+y; x x xous  $\frac{\text{Minix'} \, \text{R} \, \text{X+U:X}}{\text{S+:} \, \text{ai}^{\text{T}} \, \text{X} = \text{bi}} = \frac{\text{X}^{\text{I}} \, \text{Y}}{\text{S+:} \, \text{II}^{\text{T}} \, \text{Z} \, \text{R}^{\text{T}} \, \text{X}}} = \frac{\text{X}^{\text{I}} \, \text{Y}}{\text{S+:} \, \text{II}^{\text{T}} \, \text{Z} \, \text{R}^{\text{T}} \, \text{X}}} = \frac{\text{X}^{\text{I}} \, \text{Y}}{\text{S+:} \, \text{II}^{\text{T}} \, \text{Z} \, \text{R}^{\text{T}} \, \text{X}}} = \frac{\text{X}^{\text{I}} \, \text{Y}}{\text{X+:} \, \text{X+:} \, \text{X+$ · Quadratic function: and of find distalled it symmetries where Q=QT >0 (xTAX = xT A+ATX : A+AT symmetric) If Hzo, then fix is convex. Quadratic-constrained QP -> Shep: aP model:
min = xTHx+cTx+d min XTD. X + co do X / E min or asTx + t ... s.t. xTQ; x + a; Tx = b; s.t. | 208 = x | | = t+1 St. + AX66 14 1 1/1 1/1 1/1 1/1 1/1 where H=HT >0 (O'H)>DIC XX SHELON DAF SYFIXA) HXXX 11 · HZO; (6-12-11): xx5Htc+5, 34N(H): /p=d-(x\*) Hx\* · HZair & BUH) ni Unboinded 11. 21/2 11 = 1/21 11 walnes & Comment of a comment Proceedings of the Process of SM acardenset = अश्रामि द्वारमाई । 11741/28 श्रिमेशक

· Box uncertainty: Robust Least Squares ( 111/ Mario 11 15. U= }a:11a-à11à ≤ p311 IN MIRE A'S HA-AUSP3 THEREN ! min HAR max (AX-y1)2) 111 11 11 = [a+pu: Ilulla = 1] max at x = at x + p. (max utx) = at x + p 11x11, and polyhedron with 2n vertices min max ((A+4)x-18112 · Sphere uniertainty: · 11(A+x)x-yllz + 11xx11 + xx-x1x-y), a>0 V= {a: 11a - a42 = p} 1 MANIE & HALL SHALL SHAN STATE & SHAM TO THE P Max Hat sk = yll > HAx glist pirxlx = { \array \array \array \land  $\max_{\alpha \in \mathcal{U}} \frac{a^{T} x = \hat{a}^{T} x + \rho \left( \max_{\alpha \in \mathcal{U}} x^{T} x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( \sum_{\alpha \in \mathcal{U}} x^{T} x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( \sum_{\alpha \in \mathcal{U}} x^{T} x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( x \right) \left( x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( x \right) = \hat{a}^{T} x + \rho \left( x \right) \left( x \right) = \hat{a}^{T} x + \rho \left( x \right)$ the upper bound is obtained when "! · Ellipsoidal uncertainty: A = IIAx = yil z · IIxlb (Ax Ly xx Ti (A-1) 1) A 1? U= {a: (a-a) p-1 (a-a) = p3 Where Pro FR St. P=RTR. ( min 11 fx - y,11,+ p 11 x 11/2 5.t.; U7, 11 Ax-y1/2, (Sock) U= Fa=a+Ru: 11u11251} . 11111 1111 max atx = atx + max (Ru) Tx = atx + HRTx112 · Chance - constrained LP: Consider P = 31x(0), -, x(m), 3: min CTX · linear hull (x:x= & zix(i), +xie(R) St.: aiTx|Sbi-> where Itaily ai ~ N (ai, Zi YMIL 20 affine hull) & XII &= & XI XII), & Xi= | Axie 123 ·· E(aitx) = aitx, Var(aitx) = x/Six ( aff P 13 the smallest affine set containing P. · Convex combination: x= 2) ix(i), sai=1, xizo Vi ~> s.t.: P[a; ] > pi, pi > 0.5 · convex hull cop= {xo: x= Exixu) . Exi=1, xi70} St. α. τ'x 's bi - φ'(pi) || Σ; 2 x 1/2 (Socp) · conic hall conicP= {x: v= 8/1; x"), x; >, 0} Set CEIRN is comex if . . .... PM: 31(x) = (01/x - ai/x )/ 6,(x) ~N(0,1) Ser CERTIS a concioquial ) in 1 61(x) = 115/2×1/2 Ti(x) := (bi-aitx)/61(x) XEC/X70 =) XXEC Praix = bij = Przilx) < Tilx) >, pi · A comic hull of a sot is a convex cone ( Piz Tilx) 7, 0-1(pi)

describes tangent hyperplane · Ci is comex, ViEI > C= Civil comex · If f is differentiable. · S, : symmetric, PSD, nxn? Sn: symmetric convex fis convex => f(y)>,f(x) + \prix) T(y-x), + xiy & doms St = OF XEST: WX UBOB; Blaker convex. It & is twice differentiable, · It is a convex cone.
· If f: Rn - 1Rm is affine, CCIR is convey. fix convex 6> >2f >0 Yx Edin f f 18 conver ( gre) = fix + to) 13 convex, Yxo, V then f(c)={15.00):x+c}x18 convex 1111-11 (Fd) x = 1 v3 a family of convex functions · The projection of a convex setic onto a subspace then fix) = max faix) is convex is represented by a linear map: over { nata dom fa 3 nt { x = f work as } in the Thus the projection set is convex. · X -> MAX+bII2- (CTX+d) 13 connex! · 9:18" - 318 is convexorif 111-1 3111 21 · X -> Amax (x) = max uTXu: 11u112= 1701 WAE LOID, xiye donof = {xEIR": -0<f(x)<00} · f is concave if +it is convex !! ... · X - hax+Blig + tr (cTx) Six) = max HMullz( Six) = max II(AX+BB)ullz+ tr(CTX) Vu + (:, u) is convex. · Convex functions must be too, outside domains · epif := ?(xit), redomf telk: f(x) =t } " f is a convex function it and only of epit is a convex set · d-Sublevel sea of f: Sa:= [xolk": fix) Ed} Convex prolem: · file convey 3 So it convey set P\*= min fo(x) st: fi(x) <0, Ax=b 0 9 · If fi one convex, then fix = Saifux), xi70 is comex where fo, fi convey : 1 . log - sum-exp: function : sco /= log (Zexi) a fealible set x is convex epusiz ? Lxiti) e ikixik. Rexi-t =13 · local optimal =>, global optimal: your great exitis convex. -11. Xippt. it (convex - > = 11) March 1 Commence · fix) = Exilogx: is convexion -Ifs: R" - IR is convey => g(1x): = f(Ax+b) is convey. cathere var transf. preserves convexity) 1 - 11 1 - (3 16 × 12 16 (6.1) V > 10 11/11/2 11/11/11/19

· Claim: SK(W) & O(TW), W7,040 x · Primal Problem: ( ST) R > JV St. KV+, Emax(a, wi-v) € 18(1 Tw) px = min forex) : 1 x11. S.t.: film < 0 11/2 11/2 11/2 Prf: Note that Ky4 Emax 6, Wirn -= = max (N) W F130+ 1. + max ev, ev [ =1) + max co, WIHIJ-U)+max(0, ( [(X 12 , N) = form) f 12 2 ((X) + 8 Viho(x)) ALWY SKIWY BLW) 70 · max fix, n,v) = , story of x is feasible. (1) ta otherwise (=) Let V= WIEIT. Then A(w) = Sx(w), B(w)=0. · Mmi max, In equality in the court 1:18 cm) > Alw, +B(w) & 0(170). Franky Y -> IR 1-1/1/1 11/1/11/11/11/11 (5) SKIW) & ALW) + BLW) & O( ] CW) ... Slaters condition for convex programs: Idp px = win filx) Stil filx) Eo yfoly file convex) Sp: D-> 1R - AX=b. Erelina P Lay): Prf: V(xi,yi) & XxXi: 1 x A ! . . . . If the problems strictly feasible i.e. 7x st y plays first heyo) < Filixo, yo: ) = gexa) => max hyy) = min gex) Arosb, filx.) = <0, Vi (including implicit ineg related to the problem's domain). - LASSO: p\*=min=1|Ax-6|1=+2|17111. dx:= max min Lix, x,v) To make use of duality (transformed into convex = IRMxIR (9(2,v)) PX = mm = 112112+X11X11 5+ ... 7 = AX-b · qu'in) is a pointwise minimum of dx=max gw, gw) = = = 112112+ x lix11, + y (2-Ax+b) affine functions - ger, v) is concave. 12 layour " 11 >= VTb+ min x HxH, -x T(ATV) ~> x(x) max gy,v) is convex .... β(z) · SKIW):= & Waiz, Wais is the i-th largest 11 ( 17/1 A) = 2 A | XI - | XI (ATU) ( > E [ 2 - 1/4 TY) [ ] (XI) element inw. i, (1ATVHO E) : (RHS70, d:(80)=0=) xx(x)=0, xx=0, · Sku) = mer x u w: 1 y = k 117 11 ATVILOTA : XX(X) = 100. 1-11-B\*(3) = - = 111/1/2 pointwise maximum : Skul) 13 comex : Dual: dx = max vTb - = 111112 st: 11 AT VILL = 2

· Logistic Regression d\* = max graxy 11.211 1.21111112 11/11/11 13/21/11 px 1 max log 2 (00, b) dry):= win x(x:x') > Z log (1+, exp 6-y r w x i+6)) · KKT conditions for (x, x) pair: " " vy. 1, introduce stack var it make duality meaningful PX= max - 2 fwi) (5011 ) = ATW [YXX :- ynxm] 5 Primary Geostibility 211 111 1111 XED, five) Education 1 lix Dual feasibility willing 11 11 111 111 111 111 FLE) 1= trgette 3) The constraint is linear equality, feasible iii): Complementary slackness , 4. 11, ... = By Stated & Then 131 1 197 - 1 11 11 1 1 1 px=dx=mingovy-... giv):= max - 7 5(vi) + 2 (AT 20 - 12) in Lagrangian stationarity xell arginin & (1512) > max - 2 (fivi) + 2 vi) + VTATW if & file differentiable, then · · · · in AV+10, givi= +ax i · · · · · · · Vx fo(x) + 2 λ; Vxf;(x) = 0 in Avzon: with obgoto: him · Assume that the primal problem is attained i.e. 3x\*6D st. p\*=fox\*); the dual is attained; min f(8) + a5 = salog a+(12) logti-a) = 0 < a < | + 40, otherwise the strong duality holds. = .p\* = d\* = min-1-1(v), sti v'E[0,1], A, V=0 Then a primal pair (x, 2) is optimal (x,2) satisfies KKT conditions. 1 (H10) = - 71 (Vilog Vi+1(-Vi) log(1-Vi)) Primal Problem: concare. p\*=min fi(x) xt: fi(x) <0, JEIm). · Siones minimax than et X < IR " be concave, Y = IR" compact set. Ax=b F: Xx.Y -> IR. St. Y yx.Y, F(.,y) is convex. cont. where for fire for are convex differentiable D:= 1 dom fi over X: 14 x E(X, F'(x, .) 123" concabe, cont. over Y. AssumèlD=1k" ii) Strictly feasible (so Slate's holds) Then max min Fixy) = min max Fixy; This is attained i.e. It's D sit. Px=f.(xx) => px = minf(x), x sp denotes the feasible set. canchow that ophinal XX: AXX = 32 st. = folx) +AV=0 I A THE THE THE PARTY OF THE PA => (X2) is optimal iff KKT holds.

137A final · Recover primal solution from duard: " Unitary: u-1=u+ If b (x, x, v) has a unique minimizer (x\*, v\*) can be expressed as  $U = e^{iA}$ , A is Hermitian. If L(·, 2\*, v\*) has a unique minimized xx: Idempotent: 12=1. if xx is feasible, then it is the primal-. If A vis also Hermitian, then it is a optimal solutions: " . i will in the Projection operator, Let "4 be any operator: 4=14+ (I-1)4 if not, then no primal-orptimal stolution exists. - SAFE ( Sate feature climinations :: (1). then <14/ (I-1)47 Primal: P\* - min 11Ax - bills + wuxili sociat A = <41 n+ 17-14> = <41014> =0 dual: d\* = max bu: 1141/21, laitule piècen]. Note that I-1 is also a projection operator. If nailler, thenx laituismy Vinuisel 4= Ecnyn, cm = < 4m14> Direcdella : ith constriant is not active in the dual-→ 4+ (r') 4ncr) = 8cr-r') (closure) ~ expresses completeness of Eynz It amounts to solve primal with with feature => <X14> = 51 <7/4,><4,14> removed i i.e. Safe ito set xi=0. =. Closure relation canbe written as 214n>(41=I. 0-1217 7 11 1 11 12 12 Including continuous eigenvalues: The property of the property of the second 4 = Ecnyn + Scla) Yada Cn = < \p, 14>, c(a) = < 4a14> Clisure relation: 1 . af mely a lx > copper 24x (r') 4ncr)+ [ 4x(r') 4a(r) da= str-r') · Fundamental commutation relation: a supply of the and you have no are [x,px]=[y,py]=[z,pz]=oit (1119) 1. 1. 1/1 1. (a) 1 . (a) - (AA)2 (AB)2>) - { (FAIB]>} · 4ALB > = | <[A.B]> 1. 1 ( Tara) 11 , 49 4 3 14 4 5 5 8 14 1 1 1 1

Mina 18 1 Joseph John 18 11 1841