New features and improvements in the SeDuMi package

Imre Pólik
with
Oleksandr Romanko and Tamás Terlaky

McMaster University
Advanced Optimization Lab

MOPTA 2005, Windsor

Outline

What is SeDuMi?

- Optimization over symmetric cones
  - linear
  - second order
  - semidefinite
  - complex variables
  - free variables
- Interior point method
  - primal-dual
  - self dual embedding
  - predictor-corrector scheme
- Open source
  - GPL
  - Matlab, C
- Widely used

History

late 1997	Jos F. Sturm starts SeDuMi
summer 1998	SeDuMi 1.0
November 2002	SeDuMi 1.05R5 (last version)

- robustness, accuracy
- general success

November 2003	Jos dies

- Who will continue?

October 2004	AdvOL at McMaster takes over

- How to continue?

June 2005	SeDuMi 1.1 (new version)

Our approach

- Legal issues
- New website
  - `http://sedumi.mcmaster.ca`
  - powered by Mambo Open Source
  - 40000 visits
  - 600 registered users
  - user forum
- Bottlenecks
  - memory usage
  - time per iteration
  - Matlab
- Trends
  - ATLAS-BLAS
  - 64bit, parallel
- Our own ideas
- User input

Polling the users

What is the most important feature of SeDuMi for you?

Matlab environment	54
Open source	29
Robustness	25
Ease of use	19
Accuracy	12
Speed	12
Symmetric cones	10
Complex variables	3
	164

Development plans I.

- Preprocessing
  - widespread use in LP codes
  - significant savings
  - no theory for SOCP/SDP
  - decomposition (Kojima et. al, Plaza Martínez/Krishnan)
  - mixed techniques
- Adaptive techniques
  - corrector type
  - update method
  - step-differentiation
  - neighbourhood parameters
  - starting point (Freund)
- Sparse/dense issues
  - currently inefficient
  - ATLAS-BLAS

Development plans II.

- Converters
  - (sparse)-SDPA↔SeDuMi (SDP)
  - Mosek↔SeDuMi (SOCP)
  - modelling language support
- Miscellaneous
  - improved infeasibility detection
  - QP as SOCP
  - new search directions (with intelligent selection)
  - new scaling techniques
- Implementational issues
  - 64bit
  - parallelization
- Platform independent installer
- New user guide

Problem definition

- Primal-dual conic optimization

$$\begin{aligned} \min\ & c^T x \\ Ax &= b \\ x &\in K \end{aligned} \qquad \begin{aligned} \max\ & b^T y \\ A^T y + s &= c \\ s &\in K, \end{aligned}$$

where K is

linear $\mathbb{R}^k_+$

second order $\left\{x \in \mathbb{R}^\ell : x_1^2 \geq \|x_{2:\ell}\|^2, x_1 \geq 0\right\}$

semidefinite $\left\{X \in \mathbb{R}^{m\times m} : X \succeq 0\right\}$

or any product of these.

- User input≠solver input

Basic preprocessing I.

- Detect diagonal SDP blocks

$$\mathrm{Diag}\,(v) \succeq 0 \Leftrightarrow v \geq 0$$

  - LP in SDP
  - source: user or other format
- Free variables
  - Splitting: $x = x_+ - x_-$, $x_+, x_- \geq 0$
  - SOCP: $x_0 \geq \|x\|$
- Detecting split free variables
  - improved robustness, accuracy, less memory
  - nonlinearity, fill-in

Basic preprocessing II.

Kocvara problems	Time (s)								Iter		Time/iter (s)	
	Total		Pre		IPM		Post					
buck1	0.3	0.2	0.0	0.0	0.3	0.2	0.0	0.0	22	22	0.0	0.0
buck2	12.7	5.8	0.0	0.0	12.7	5.8	0.0	0.0	38	40	0.3	0.1
buck3	1152.5	427.5	0.7	0.3	1150.8	426.9	1.0	0.3	64	75	18.0	5.7
buck4	12329.8	3971.4	6.3	2.1	12314.5	3966.6	9.0	2.7	64	76	192.4	52.2
buck5	m	122176.5	m	29.3	m	122105.9	m	41.3	m	110	m	1110.1
mater-1	0.3	0.2	0.0	0.0	0.3	0.2	0.0	0.0	21	21	0.0	0.0
mater-2	1.2	1.2	0.0	0.1	1.2	1.1	0.0	0.0	25	25	0.0	0.0
mater-3	5.6	5.6	0.1	0.9	5.5	4.7	0.0	0.0	27	27	0.2	0.2
mater-4	23.9	30.9	0.3	10.6	23.5	20.3	0.1	0.1	30	30	0.8	0.7
mater-5	69.7	108.1	0.8	50.2	68.7	57.7	0.3	0.2	33	33	2.1	1.7
mater-6	184.4	420.8	2.1	216.1	181.7	204.4	0.7	0.3	35	36	5.2	5.7
shmup1	0.4	0.3	0.0	0.0	0.3	0.3	0.0	0.0	17	16	0.0	0.0
shmup2	741.2	512.6	0.6	0.5	739.9	511.5	0.7	0.6	39	42	19.0	12.2
shmup3	8484.0	7061.4	5.2	4.1	8473.0	7053.0	5.8	4.2	51	61	166.1	115.6
shmup4	68360.6	61161.8	32.5	24.0	68292.9	61112.6	35.3	25.1	63	88	1084.0	694.5
trto1	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	21	21	0.0	0.0
trto2	14.7	4.2	0.0	0.0	14.6	4.2	0.0	0.0	36	37	0.4	0.1
trto3	752.4	128.8	0.6	0.2	750.9	128.6	0.8	0.1	50	59	15.0	2.2
trto4	9080.1	2225.4	5.6	1.2	9066.7	2222.8	7.8	1.4	61	73	148.6	30.4
trto5	m	45465.7	m	16.0	m	45428.3	m	21.3	m	95	m	478.2
vibra1	0.3	0.2	0.0	0.0	0.3	0.2	0.0	0.0	26	25	0.0	0.0
vibra2	12.5	5.4	0.0	0.0	12.4	5.3	0.0	0.0	41	43	0.3	0.1
vibra3	1104.5	301.2	0.7	0.2	1102.9	300.6	1.0	0.3	68	69	16.2	4.4
vibra4	13565.5	3812.2	6.3	2.0	13550.1	3807.4	9.0	2.7	77	78	176.0	48.8
vibra5	m	123712.3	m	32.0	m	123639.0	m	41.3	m	126	m	981.3

Step differentiation

- Primal-dual stepsizes
- Implemented but not used - why?
  - too much, too soon
- Good if
  - close to convergence
  - numerical problems
- Step-differentiation is turned on
  - after 20 iterations
  - if $0.9 \leq$feasratio≤ 1.1
  - if CG refinement is needed
- Works surprisingly good!

Future plans

- Preprocessing
  - decomposing narrow-band matrices
  - LP techniques on the linear part
  - develop new techniques
- Adaptive components
  - starting point in self-dual model
  - refined step-differentiation
  - corrector selection
  - gathering data about parameters
- ATLAS-BLAS
- Infeasibility detection
  - infeasible SDP library
  - weak infeasibility
- QP as SOCP

New features and improvements in the SeDuMi package

Imre Pólik
with
Oleksandr Romanko and Tamás Terlaky

McMaster University
Advanced Optimization Lab

MOPTA 2005, Windsor