

What is CVX?

- ▶ CVX is a modeling system for convex optimization problems
- ▶ Website: <http://cvxr.com/cvx>

Installation on Corn

In terminal

```
$ ssh -Y SUNETID@corn.stanford.edu  
$ wget http://web.cvxr.com/cvx/cvx-a64.tar.gz  
$ tar -xvf cvx-a64.tar.gz  
$ module load matlab  
$ matlab &
```

In MATLAB

```
>> cd cvx  
>> cvx_setup
```

Structure of convex problem

Mathematically

$$\begin{aligned} & \text{minimize} && f_0(x) \\ & \text{subject to} && f_i(x) \leq 0, \quad i = 1, \dots, m \\ & && h_i(x) = 0, \quad i = 1, \dots, p \end{aligned}$$

In CVX

```
cvx_begin
    variables x(n)
    minimize(f0(x))
    subject to
        f(x) <= 0
        A * x - b == 0
cvx_end
```

NB: f_0 and f_i must be convex and h_i must be affine

Return values

Upon exit, CVX sets the variables

- ▶ x – solution variable(s) x^*
- ▶ `cvx_optval` – the optimal value p^*
- ▶ `cvx_status` – solver status (Solved, Unbounded, Infeasible, ..)
- ▶ ...

Examples – Basic

Optimization problem

$$\begin{array}{ll}\text{minimize} & x + y \\ \text{subject to} & x \geq 1, \quad y = 2.\end{array}$$

In CVX:

```
cvx_begin
    variables x(1) y(1)
    minimize(x + y)
    subject to
        x >= 1
        y == 2
cvx_end
```

Examples – Basic

CVX returns a solution and status

```
>> x
    1

>> y
    2

>> cvx_optval
    3

>> cvx_status
Solved
```

Examples – LP

Optimization problem

$$\begin{array}{ll}\text{maximize} & c^T x \\ \text{subject to} & Ax = b \\ & x \succeq 0\end{array}$$

In CVX:

```
cvx_begin
    variables x(n)
    maximize(c' * x)
    subject to
        A * x == b
        x >= 0
cvx_end
```

Examples – SDP

Optimization problem

$$\begin{array}{ll}\text{minimize} & \|X - A\|_2 \\ \text{subject to} & X \succeq 0\end{array}$$

In CVX:

```
cvx_begin sdp
    variable X(n, n)
    minimize(norm(A - X))
    subject to
        X >= 0
cvx_end
```


Examples – Assignments

Optimization problem

$$\text{minimize} \quad \sum_i \|x - a_i\|_2$$

In CVX:

```
cvx_begin
    variable x(n)
    OBJ = 0
    for i = 1:n
        OBJ = OBJ + norm(x - A(:,i));
    end
    minimize(OBJ)
cvx_end
```

NB: This can be *really slow* for large loops!

CVX Pitfalls

- ▶ Use `==` for equality constraints, not `=`
- ▶ Use `>=` and `<=` instead of `>` and `<`
- ▶ Each functions must be convex on its domain (not just in feasible region).

Resources

- ▶ CVX documentation <http://web.cvxr.com/cvx/doc/>
- ▶ Disciplined convex optimization <http://dcp.stanford.edu/>

Questions?