Hands-on CasADi course on optimal control, Yacoda

Cheatsheet

Setting up an environment for the exercises:

```
import casadi.*
```

Creating symbols:

```
x = MX.sym('x');
p = MX.sym('p');
v = MX.sym('v',3);
m = MX.sym('m',3,4);
class(x) % casadi.MX
```

Operations:

```
[x p] % Horizontal concatenation
[x;p] % Vertical concatenation
norm(v,2) % Take a two-norm
m'*v % Matrix transpose and multiply
sum(m,1) % Sum all rows
sum(m,2) % Sum all columns
```

Creating CasADi Functions:

```
f = Function('f',{x},{sin(x)})
    f:(i0)->(o0) MXFunction
g = Function('g',{x,v},{sin(x),v*x})
    g:(i0,i1[3])->(o0,o1[3]) MXFunction
r = Function('r',{x,v},{sin(x),v*x},{'x','v'},{'a','b'})
    r:(x,v[3])->(a,b[3]) MXFunction
```

Calling CasADi Functions:

```
a = f(1)
[a,b] = g(1,[1 2 3])
z = r('x',1,'v',[1 2 3]);
z.a
z.b
```

Convert to native numeric:

```
a = full(f(1))
```

Integrate ODE $\frac{dx}{dt} = f(x,p,t)$ from $x(t_0)$ to $x(t_f)$:

```
ode = struct;
ode.x = x;
ode.p = p;
ode.t = t;
ode.ode = x^2+p-t;

opts = struct('t0',0,'tf',1);
I = integrator('I','cvodes',ode,opts)

r = I('x0',1)
r.xf
```

Root-finding $g(x,p) = 0$. Find x, given p:

```
rf = struct;
rf.x = x;
rf.p = p;
rf.g = sin(x)-p;

S = rootfinder('S','newton',rf)

r = S('x0',0,'p',0.5)
r.x
```

Solve NLP

$$\begin{aligned} \underset{x}{\text{minimize}} \quad & f(x,p) \\ \text{subject to} \quad & \text{lbg} \leq g(x,p) \leq \text{ubg} \\ & \text{lbx} \leq x \leq \text{ubx} \end{aligned}$$

```
nlp = struct;
nlp.x = x;
nlp.p = p;
nlp.f = x^2+p;
nlp.g = sin(x-p);
S = nlpsol('S','ipopt',nlp)

r = S('x0',0,'p',0,
  lbg',-2,'ubg',2,'lbx',-inf,'ubx',inf)

r.x
r.lam_g
```

```
opti = Opti();

x = opti.variable();
p = opti.parameter();

opti.minimize(x^2+p);
opti.subject_to(-2<=sin(x-p)<=2);
options = struct;
opti.solver('ipopt',options);

opti.set_initial(x,0);
opti.set_value(p,0);
sol = opti.solve();

sol.value(x)
```

Collect expressions:

```
y = {};
for i=1:10
  y{end+1} = i*x^2;
end
y = vertcat(y{:});
```