Hands-on CasADi course on optimal control, Yacoda

Cheatsheet

Setting up an environment for the exercises:

```
from pylab import *
from casadi import *
```

Creating symbols:

```
x = MX.sym("x")
p = MX.sym("p")
v = MX.sym("v",3)
m = MX.sym("m",3,4)
print(type(x)) # casadi.MX
```

Operations:

```
x = MX.sym("x")
p = MX.sym("p")
v = MX.sym("v",3)
m = MX.sym("m",3,4)
```

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,vertcat(1,2,3))
z = r(x=1,v=vertcat(1,2,3))
z["a"]
z["b"]
```

Convert to native numeric:

```
a = np.array(f(1))
```

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

```
ode = {}
ode["x"] = x
ode["p"] = p
ode["t"] = t
ode["ode"] = x**2+p-t

opts = {"t0":0,"tf":1}
I = integrator("I","cvodes",ode,opts)

r = I(x0=1)
```

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

```
rf = {}
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

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

```
nlp = {}
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"]
```

```
opti = Opti()

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

opti.minimize(x**2+p);
opti.subject_to(-2<=(sin(x-p)<=2));
options = {}
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 in range(10):
  y.append(i*x**2)
y = vcat(y)
```