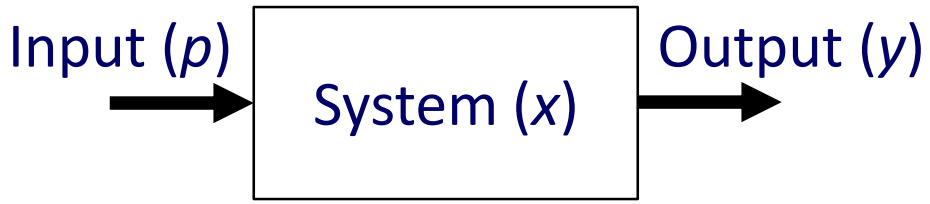
Part III: Dynamic Control / Optimization

- Dynamic Modeling
  - Empirical
  - Fundamental
- Dynamic Estimation
- **Dynamic Control / Optimization**

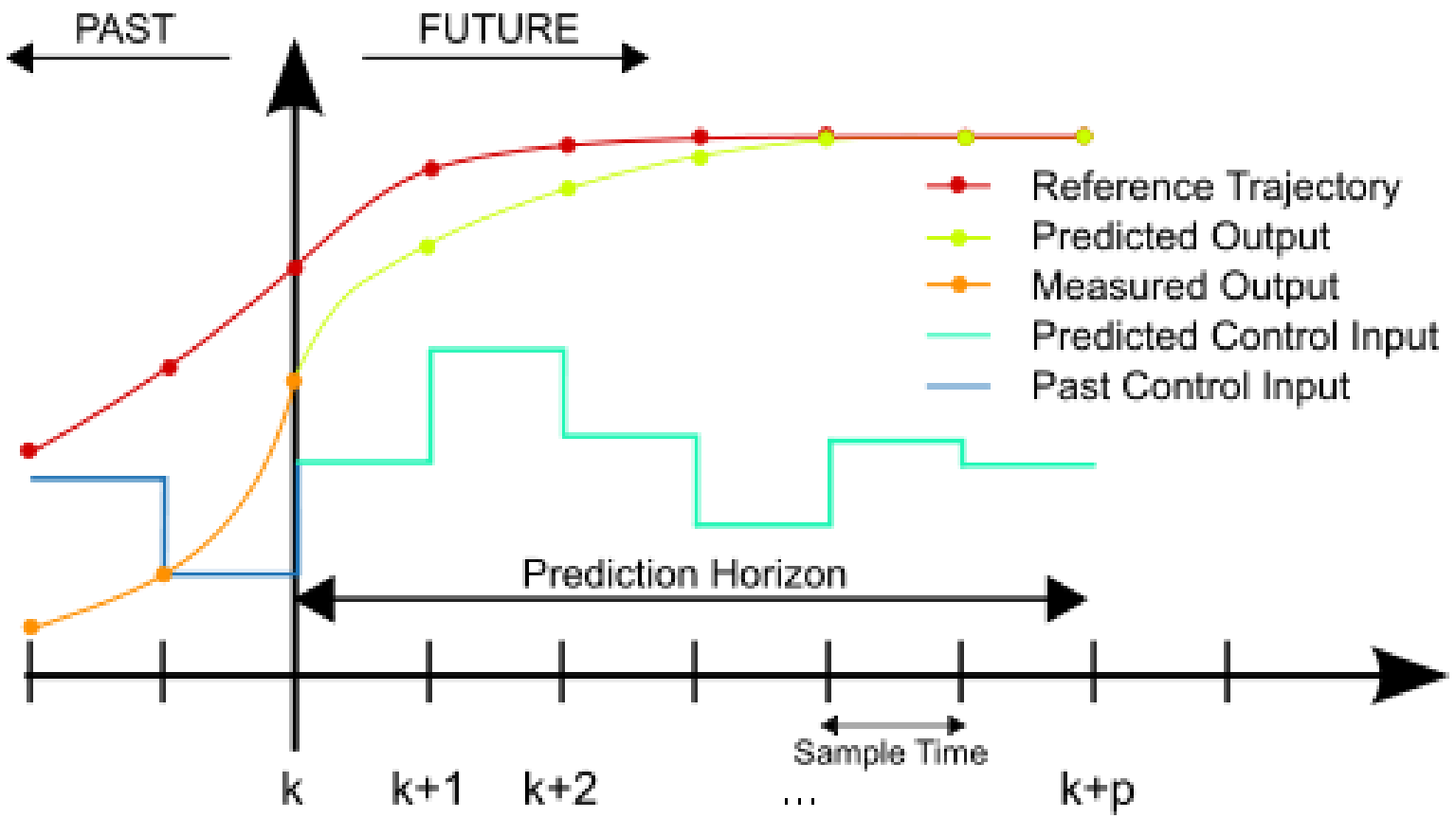
$$\underset{p}{\text{minimize}} \quad \|y_t - y\|_n$$

$$subject\ to \quad 0 = f\left(\frac{dx}{dt}, x, y, p\right)$$

$$0 \leq g\left(\frac{dx}{dt}, x, y, p\right)$$

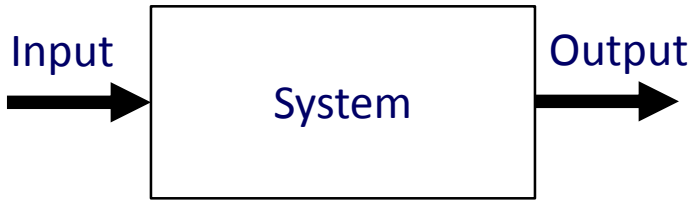


Model Predictive Control



Source: Wikipedia

Dynamic Control in Excel

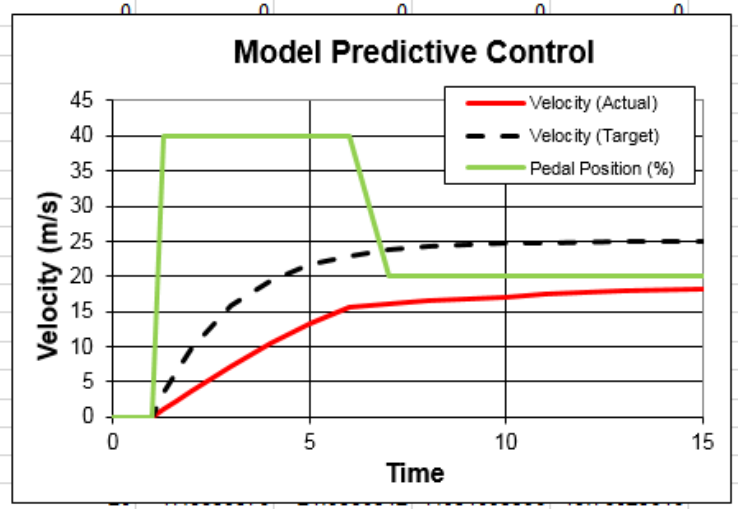


$$\underset{p}{\text{minimize}} \qquad (v_t - v)^2$$

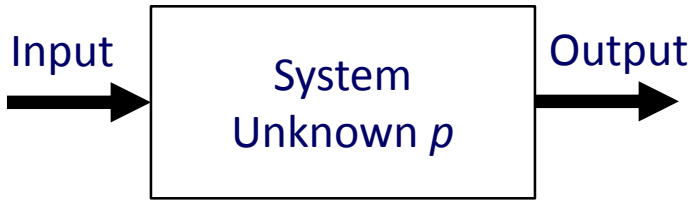
$$s.t. \qquad \tau \frac{dv}{dt} = -v + K\,p$$

$$0 \le p \le 100$$

	A	B	C	D	E	F	G	H	I	J	K
1	**Model Predictive Control**				Change	u	y	Target			
2				**time**	**Delta MV**	**manipulated**	**model**	**desired**	**abs(error)**	**error^2**	
3				0		0	0	0	0	0	
4				0.2	0						
5	**Model Parameters**			0.4	0						
6	**gain (K)**	1		0.6	0						
7	**tau (τ)**	10		0.8	0						
8				1	0						
9	**Target Trajectory Parameters**			1.3	40						
10	**Final Target**	25		1.6	0						
11	**Time Constant (tau)**	2		2	0						
12	**Delay (theta)**	1		3	0						
13				4	0						
14				5	0						
15	**Minimize Either of These**			6	0						
16	**Sum of Squared Errors**	721.2571		7	-20						
17	**Sum of Absolute Errors**	97.52808		8	0						
18				9	0						
19				10	0						
20				11	0						
21				13	0						
22				15	0	20	18.26751464	24.97720295	6.709688314	45.01991727	
23											



Dynamic Control in MATLAB



$$\underset{p}{\text{minimize}} \qquad (v_t - v)^2$$

$$s.t. \qquad \frac{m}{b}\frac{dv}{dt} = -v + K\,p$$

$$0 \le p \le 100$$

Dynamic Control in MATLAB

Setup

```
clear all; close all; clc % clear session
addpath('apm') % load APMonitor.com toolkit

s = 'http://byu.apmonitor.com';
a = 'velocity';

% clear prior application
apm(s,a,'clear all');

% load model and data
apm_load(s,a,'ferrari.apm');
csv_load(s,a,'ferrari.csv');

% specify MV / CV
apm_info(s,a,'MV','p');
apm_info(s,a,'CV','v');

% configuration parameters
apm_option(s,a,'nlc.imode',6);
apm_option(s,a,'nlc.nodes',3);
```

Tune and Solve

```
% turn on MV / CV
apm_option(s,a,'v.status',1);
apm_option(s,a,'p.status',1);

% tune controller
apm_option(s,a,'p.lower',0);
apm_option(s,a,'p.upper',100);
apm_option(s,a,'v.tau',5);
apm_option(s,a,'v.sphi',26);
apm_option(s,a,'v.splo',24);

% solve and retrieve results
output = apm(s,a,'solve'); disp(output);
y = apm_sol(s,a); z = y.x;

% open web-viewer
apm_web(s,a);
```

Dynamic Control Solver Summary

```
Number of state variables:            960
Number of total equations: -          930
Number of slack variables: -            0
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Degrees of freedom       :             30
-----------------------------------------
Dynamic Control with APOPT Solver
-----------------------------------------
Iter    Objective  Convergence
   0  1.95086E+04  6.25000E+00
   1  4.70028E+02  1.00000E-10
   2  4.70028E+02  7.17063E-06
   3  4.70028E+02  7.10543E-15
Successful solution
---------------------------------------------------
Solver         :  APOPT (v1.0)
Solution time  :   0.270199999999022      sec
Objective      :    470.028094918699
Successful solution
---------------------------------------------------
```

Dynamic Control MATLAB Results