DERIVATIVE COMPUTATION BY 1D CONVOLUTION

```
F[n] = {1.0, 1.11, 1.35, 1.20, 4.32, 2.1, 0.11, -2.1, -1.1, 7.32};
Forward Difference Kernel = {1,-1,0};
Backward Difference Kernel = {0,1,-1};
Central Difference Kernel = {0.5,0,-0.5};
```

main.c

main.c › main()

```
    switch (mthd) {
        case 1:
            //Forward Difference
            for (i = istart; i <= iend; i++) {
                h[i] = 0;
                p = &kforw[1];
                for (a = -1; a <= 1; a++){
                    if(((i-a) > iend)||((i-a) < istart))
                        h[i] += 0;
                    else
                    h[i] += p[a]*f[i-a];
                }
            }
            strcpy(DerMthd, "Forward Difference");
            break;
        case 2:
            //Backward Difference
            for (i = istart; i <= iend; i++) {
                h[i] = 0;
                p = &kback[1];
                for (a = -1; a <= 1; a++){
                    if(((i-a) > iend)||((i-a) < istart))
                        h[i] += 0;
                    else
                    h[i] += p[a]*f[i-a];
                }
            }
            strcpy(DerMthd, "Backward Difference");
            break;
        case 3:
            //Central Difference
            for (i = istart; i <= iend; i++) {
                h[i] = 0;
                p = &kcentr[1];
                for (a = -1; a <= 1; a++){
                    if(((i-a) > iend)||((i-a) < istart))
                        h[i] += 0;
                    else
                    h[i] += p[a]*f[i-a];
                }
            }
            strcpy(DerMthd, "Central Difference");
            break;
        default:
            goto end;
            break;
    }
```

```
funa@funa-VirtualBox:~/Documents/CMPE242/LAB2/HW3/derivative_calc$ ./output
Select approximation method:
(1) Forward Difference
(2) Backward Difference
(3) Central Difference
(4) Quit

:::: >>>>  1

Forward Difference Derivative Computation result:

h[n] = {0.11, 0.24, -0.15, 3.12, -2.22, -1.99, -2.21, 1.00, 8.42, -7.32}

Select approximation method:
(1) Forward Difference
(2) Backward Difference
(3) Central Difference
(4) Quit

:::: >>>>  2

Backward Difference Derivative Computation result:

h[n] = {1.00, 0.11, 0.24, -0.15, 3.12, -2.22, -1.99, -2.21, 1.00, 8.42}

Select approximation method:
(1) Forward Difference
(2) Backward Difference
(3) Central Difference
(4) Quit

:::: >>>>  3

Central Difference Derivative Computation result:

h[n] = {0.56, 0.18, 0.04, 1.49, 0.45, -2.10, -2.10, -0.61, 4.71, 0.55}

Select approximation method:
(1) Forward Difference
(2) Backward Difference
(3) Central Difference
(4) Quit

:::: >>>>
```

PID CONTROLLER TEST RESULTS

$$Error = \frac{Cntl(output)}{Control(PID) \bullet VehModel}$$ (Closed Loop Equation)

$$Error[n] = x[n] - h[n]$$

Proportional Control: $K_p * Error[n]$

Integral of Past Performance (Integral Control): $K_I \int_{\Omega} Error^2[n]dn$

Changing rate of function (Derivative Control): $K_d \frac{dError}{dn}$

SumError = Proportional Control + Integral Control + Derivative Control

$$F_{pwm} = \frac{1}{2} SumError\ [n]$$

Central Difference kernel k[b] for Derivative Control computation:

0.5	0	-0.5

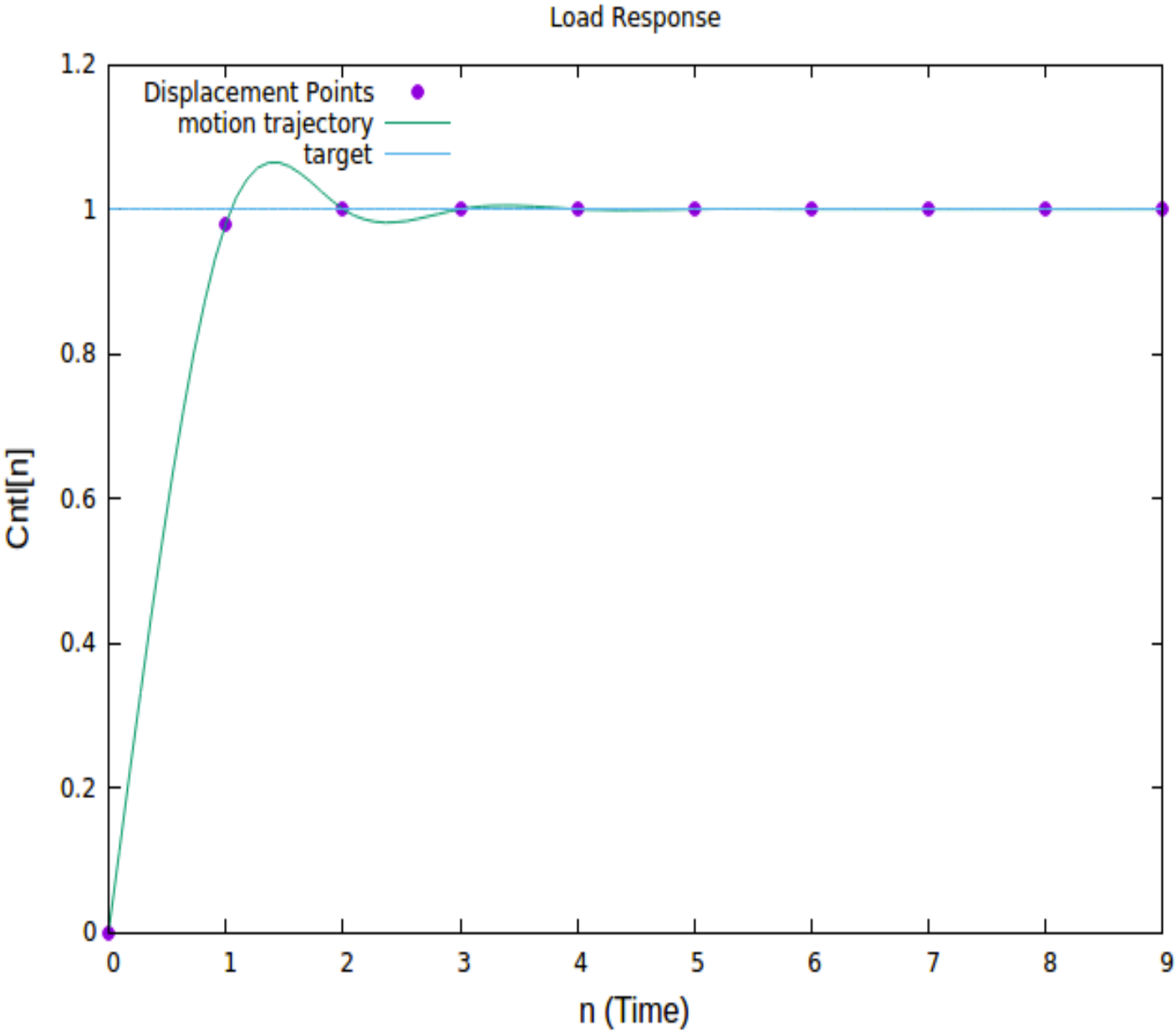
$$CDError[n] = \sum_{b=-1}^{b=1} k[b] * Error[n-b]$$

1x7 Gaussian Kernel g[b] for 1D Convolution of H[n] ($\sigma = 6\ pixels$):

0.0587	0.0629	0.0656	0.0665	0.0656	0.0629	0.0587

$$hprime[n] = \sum_{b=-3}^{b=3} g[b] * h[n-b]$$

```
funa@funa-VirtualBox: ~/Documents/CMPE242/LAB2/HW3/hw3_ver_ubuntu/pid_controller
funa@funa-VirtualBox:~/Documents/CMPE242/LAB2/HW3/hw3_ver_ubuntu/pid_controller$ ./output

PID Controller Computation results:

x[n] = {1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00}

Contl[n] = {0.0000, 0.9802, 0.9971, 1.0036, 1.0038, 1.0001, 1.0000, 1.0000, 1.0000, 1.0000}

Error[n] = {1.0000, 0.0198, 0.0029, -0.0036, -0.0038, -0.0001, -0.0000, -0.0000, -0.0000, -0.0000}

CDError[n] = {0.0000, -0.5000, -0.0099, -0.0015, 0.0018, 0.0019, 0.0001, 0.0000, 0.0000, 0.0000}

IError[n] = {1.0000, 1.0004, 1.0004, 1.0004, 0.0004, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000}

Kp = 10.00; Ki = 10.00; Kd = 10.00

alphaP = 26.00; alphaI = 0.10; alphaD = 0.33

SumError[n] = {261.0000, 4.4996, 1.7303, 0.0713, -0.9875, -0.0247, -0.0067, -0.0003, -0.0001, -0.0000
}

fpulse[n] = {50.0000, 130.5000, 2.2498, 0.8651, 0.0356, -0.4937, -0.0124, -0.0034, -0.0002, -0.0000}

N_pwm[n] = {50.0000, 130.5000, 2.2498, 0.8651, 0.0356, -0.4937, -0.0124, -0.0034, -0.0002, -0.0000}

Ang[n] = {0.0463, 29.4088, 29.9150, 30.1097, 30.1177, 30.0066, 30.0038, 30.0030, 30.0030, 30.0030}

disVe[n] = {0.0463, 0.9802, 0.9971, 1.0036, 1.0038, 1.0001, 1.0000, 1.0000, 1.0000, 1.0000}

Error[n+1] = {0.0198, 0.0029, -0.0036, -0.0038, -0.0001, -0.0000, -0.0000, -0.0000, -0.0000,NULL}

funa@funa-VirtualBox:~/Documents/CMPE242/LAB2/HW3/hw3_ver_ubuntu/pid_controller$
```


Load Response
Displacement Points
motion trajectory
target
Cntl[n]
n (Time)
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9

	A	B	C	D	E	F	G	H	I	J	K
1	n (Time)	0	1	2	3	4	5	6	7	8	9
2	x(n)	1	1	1	1	1	1	1	1	1	1
3	Contl(n)	0	0.9802	0.9971	1.0036	1.0038	1.0001	1	1	1	1
4	Error(n)	1	0.0198	0.0029	-0.0036	-0.0038	-0.0001	0	0	0	0
5	K_p	10	10	10	10	10	10	10	10	10	10
6	cDError[n]	0	-0.5	-0.0099	-0.0015	0.0018	0.0019	0.0001	0	0	0
7	K_d	10	10	10	10	10	10	10	10	10	10
8	K_i	10	10	10	10	10	10	10	10	10	10
9	IError[n]	1	1.0004	1.0004	1.0004	1.0004	0	0	0	0	0
10	alpha_p	26	26	26	26	26	26	26	26	26	26
11	alpha_i	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12	alpha_d	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
13	SumError[n]	261	4.4996	1.7303	0.0713	-0.9875	-0.0247	-0.0067	-0.0003	-0.0001	0
14	Fpwm(Hz)	50	130.5	2.2383	0.8647	0.0355	-0.4938	-0.0123	-0.0034	-0.0002	0
15	N_pwm[n]	50	130.5	2.2383	0.8647	0.0355	-0.4938	-0.0123	-0.0034	-0.0002	0
16	Ang(n)	0.0463	29.4088	29.9124	30.107	30.115	30.0039	30.0011	30.0003	30.0003	30.0003
17	SpeedVe[n]	1.389	29.4088	14.9562	10.0357	7.5287	6.0008	5.0002	4.2858	3.75	3.3334
18	disVe(n)	0.0463	0.9803	0.9971	1.0036	1.0038	1.0001	1	1	1	1
19	e[n+1]	0.0198	0.0029	-0.0036	-0.0038	-0.0001	0	0	0	0	NULL