


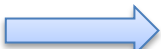





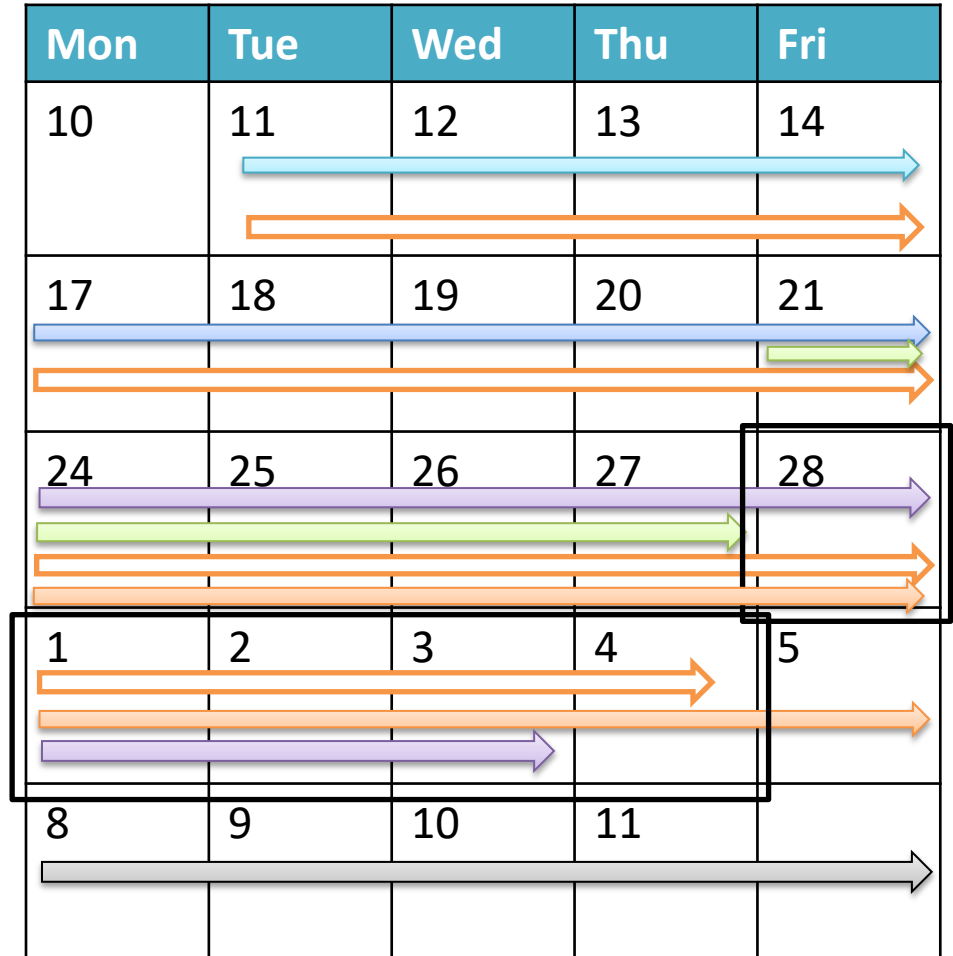
PJ : Cold Brew Machine

조원 : 홍기화

[프로젝트 일정]

6/28~7/4

-  DSP(Camera)
-  Sensor fix(고장 수리)
-  Digital Filter
-  WebGL
-  Integration
-  Debug
-  Communication(dsp<->mcu)



[Project Goal]

Cold Brew Coffee Automation System

Weekly Goal

←---- optional
←----- mandatory

1 Ground Coffee Analysis

DSP(OpenCV)

Camera USB 3.0 1920 x 1280

Data 1 : Color(RGB)

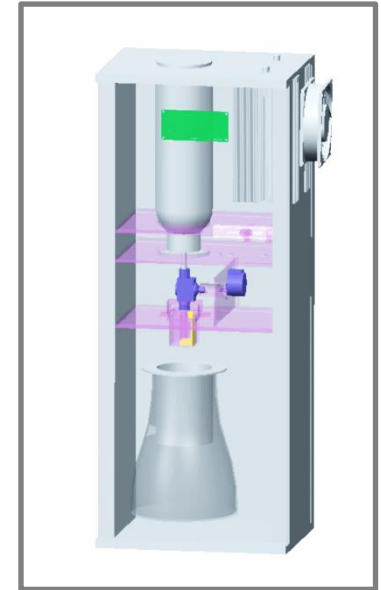
Data 2 : Size(mm²)

Under Dark Room and LED light

Under Dark Room and LED light

Filter all but the ground coffee
-> Average the color of the dots

Brightness normalization ->
DFT -> range -> size



2 Sensor Data Processing(Digital Filter)

Weight Sensor Data -> ADC(<=3mV Change)

Temperature Sensor Data -> ADC

ADC -> Digital Filter(LPF)

Where 1 : Weight Sensor

Where 2 : Temperature Sensor

UDP
Data Log

Digital
Filter

[Project Goal]

Cold Brew Coffee Automation System

Weekly Goal

←---- optional
← mandatory

3 Drop Display On Web

WebGL

Water Drop Visualization

Display Data

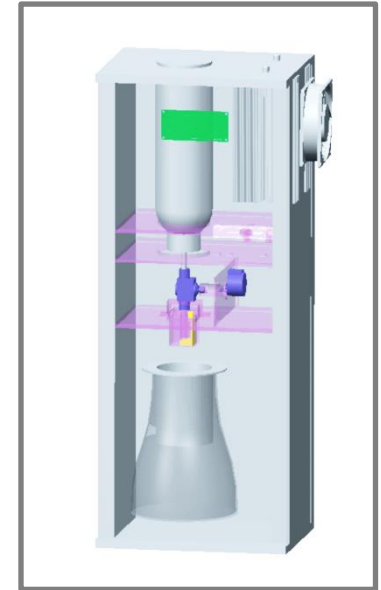
IR Remote -> Web

Ground coffee (size)

Display data

Ground coffee (color)

Select settings



4 Integration

→ 1. MCU (FreeRTOS : UDP + Peripheral + Digital Filter)

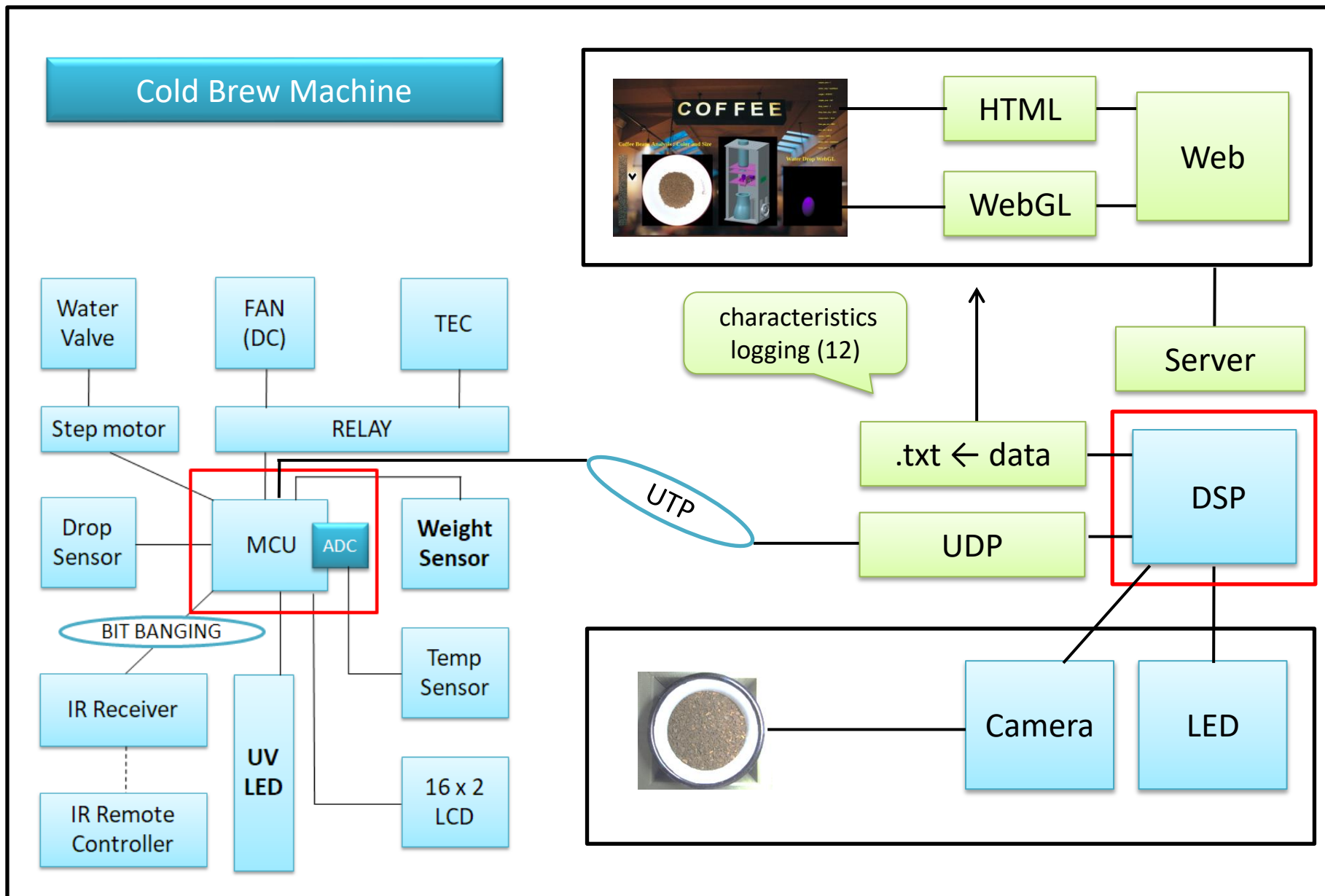
→ 2. DSP : Web Server + Camera(OpenCV) + UDP + File(.txt)

→ 3. Web(text read in background + image load(14) + WebGL)

→ 4. DSP <-> Web (Web: .txt reading + DSP: .txt Writing)

[PJ CBM : 진행 상황]

❑ System Abstraction



[PJ CBM : BOM]

대분류	소분류	품명	수량(ea)	단위가격(원)	총액(원)
electronic parts	MCU	TI tms570 launchpad	1	37570	37570
	LCD	LC1621 LCD	1	7700	7700
	Weight Sensor	Load cell BND-611N 1kg	2	25300	50600
	Weight Sensor	Load cell BND-611N 2kg	1	14500	14500
	Weight sensor adc IC	HX711 Module (24bit AD)	1	1540	1540
	Drop Sensor	photo interrupter	3	1760	5280
	Temperature sensor	ETH-01DV	1	8910	8910
	UV-LED	uv-c 4545 smd led 5mW	3	5000	15000
	IR receiver + control board	(chinese)	1	2000	2000
	step motor controller	ULN2003 Module	1	1300	1300
	step motor for valve control	28BYJ-48	1	1200	1200
	FAN		1	17500	17500
	TEC Module	TEC-12705	2	5400	10800
	Relay		2	2000	4000
	Camera	usb3.0	1	75000	75000
Mechanical parts	door switch	ramps 1.4 limit switch	3	2400	7200
	펄티어 단열스폰지	펄티어 단열스폰지	1	600	600
	Peltier heatsink	Peltier-Heatsink-Set(협신전자)	1	16500	16500
	LED PCB	smd led 기판	1	1800	1800
	투명 튜브	에어호스 6mm	1	800	800
	electric wire	0.35Q × 12C 10color 1m	1	1300	1300
	wire mold	wire duct PVC 사각몰드 밤색 1호	3	300	900
	문 경첩	경첩	2	1000	2000
	문고리	문고리	1	1000	1000
	문자석	문 자석	1	1200	1200
	case	플라베니아 5T 회색	1	4950	4950
	단열재	압축스티로폼 20mm	1	2000	2000
	물병	물병 티보틀	1	5000	5000
	실리콘마개	SL.Sto6105 (싸이랩코리아)	1	4500	4500
	Water valve	FSC0600 호스6mm 미세조절	1	2600	2600
	Water tank	daiso 1001333	2	1760	3520
	Li-po 2800mAh 35C	Li-po 2800mAh 35C	1	51900	51900
	3D Printer	Ender 3	1	230000	230000
	3d print 필라멘트	PLA 필라멘트 1kg	2	17500	35000
	볼트너트	m3,m4,m5 볼트 너트 와셔 세트(은색)	1	6100	6100
	더치기구	더치기구	1	19500	19500
합계 총액					647,750

[PJ CBM : 진행 상황]

❑ DSP : Camera DCT

문제 상황 : DCT 실험결과 불안정

➡ 빛의 양에 따라 값이 달라짐을 확인

조명이 1mm 틀어져도 아래와 같은 값 변화 발생

```
r : 491
center : 1112,520
channel num : 3
type : 16
before avg 0 : 177.049 avg 1 : 125.051 avg 2 : 132.695
after avg 0 : 169.049 avg 1 : 125.051 avg 2 : 132.695
total dots = 826844, coffee dots = 396805, blackdots = 270076, whitedots = 159963, coffee avg 1st r = 104, g = 94, b = 78
white dots = 159963, white r = 56, g = 42, b = 31
coffee avg expected color r = 160, g = 136, b = 109
: 78725.7, 19042.5, -24539.8, 9663.99, -8135.68, 2268.52
: -2711.5, -124.771, 1391.31, -558.773, 402.949, 188.219
: -6219.44, 1425.54, -20608.5, -17918.3, 2252.31, -12908
: -1253.21, -555.726, 2291.4, 936.348, -825.794, 852.159
: -2040.53, -497.178, -7703.87, -10059.2, 9474.25, 6395.68
dc : 0
multiplied avg : 7.72135e+07
mean : [-25.04161437425045]
stddev : [1330.797290373792]
image processing finished!
Web Server
^Cterminator sig = 2
root@am57xx-evm:~/gihwahong/web_physics# ./a.out
r : 494
center : 1098,524
channel num : 3
type : 16
before avg 0 : 195.096 avg 1 : 126.37 avg 2 : 132.089
after avg 0 : 169.096 avg 1 : 126.37 avg 2 : 132.089
total dots = 837824, coffee dots = 390535, blackdots = 273092, whitedots = 174197, coffee avg 1st r = 108, g = 95, b = 83
white dots = 174197, white r = 55, g = 47, b = 39
coffee avg expected color r = 163, g = 142, b = 122
: 81215.6, 18287.2, -25901.8, 9918.77, -9336.97, 2515.87
: -3485.98, -300.808, 1888.89, -567.253, 450.484, 345.833
: -7401.54, 1567.79, -20818.4, -17701.7, 3408.25, -13239.4
: -1009.6, -546.771, 2451.76, 1278.97, -1101.86, 767.938
: -2760.17, -383.382, -7035.98, -10199.4, 10187.8, 6657.7
dc : 0
multiplied avg : 8.33132e+07
mean : [-26.02805179340839]
stddev : [1344.970811281962]
image processing finished!
Web Server
```

[PJ CBM : 진행 상황]

❑ DSP : Camera DCT

문제 상황 : 빛에 일정한 DCT값 산출 위한 이미지 색상 처리

- ⇒ 빛에 대한 채널이 있는 이미지 색으로 변경
- ⇒ 빛 값을 일정하게 만들고 이미지 재변환(to RGB)

<이상태(Lab)에서 dct 결과 비교>

```
r : 492
center : 1126,534
dc : 0
multiplied avg : 9.01908e+07 원본(어두움) -> dct
channel num : 3
type : 16
before avg 0 : 176.443 avg 1 : 126.496 avg 2 : 131.411
after avg 0 : 169.443 avg 1 : 126.496 avg 2 : 131.411
total dots = 830496, coffee dots = 395957, blackdots = 271088, whitedots = 163451,
white dots = 163451, white r = 53, g = 42, b = 30
coffee avg expected color r = 160, g = 137, b = 114
: 80484.7, 19581.1, -25467, 9844.13, -7977.12, 1997.26
: -3421.05, -185.946, 1955.5, -530.307, 402.521, 272.089
: -6461.81, 1426.96, -20749.4, -18531.2, 2128.22, -12824.7
: -1174.74, -498.746, 2416.51, 913.938, -1021.00, 774.737
: -2383.76, -621.815, -7683.84, -18149.5, 9593.56, 6747.15
dc : 0
multiplied avg : 8.11217e+07 원본(어두움)-> Lab 밝기변환 -> dct
mean : [-25.7402305154562]
stddev : [1350.432775927466]
image processing finished!
Web Server
^Cterminator sig = 2
root@am57xx-evm:~/gihwahong/web_physics# ./a.out
r : 496
center : 1126,544
dc : 0
multiplied avg : 1.22547e+08 원본(밝음) -> dct
channel num : 3
type : 16
before avg 0 : 184.5 avg 1 : 125.548 avg 2 : 131.945
after avg 0 : 169.5 avg 1 : 125.548 avg 2 : 131.945
total dots = 845104, coffee dots = 307330, blackdots = 275100, whitedots = 182754,
white dots = 182754, white r = 47, g = 37, b = 31
coffee avg expected color r = 159, g = 136, b = 117
: 86083.5, 16133.2, -30117.6, 11641.6, -9772.14, 2773.64
: -8331.65, -1742.62, 4210.55, -489.705, 1119.2, 1059.39
: -7641.04, 3595.65, -21010.7, -18860.7, 4812.23, -13814
: -1134.86, -692.097, 4854.62, 3383.66, -2182.11, 867.619
: -4116.77, -220.332, -6081.65, -11341, 10510.5, 7290.84
dc : 0
multiplied avg : 9.96369e+07 원본(밝음)-> Lab 밝기변환 -> dct
mean : [-27.7352389547245]
stddev : [1431.814834593234]
```

<이상태(YCbCr)에서 dct 결과비교>

```
r : 498
center : 1104,524
dc : 0
multiplied avg : 8.78544e+07 원본(어두움) -> dct
channel num : 3
type : 16
before avg 0 : 173.261 avg 1 : 126.848 avg 2 : 123.76
after avg 0 : 169.261 avg 1 : 126.848 avg 2 : 123.76
total dots = 823200, coffee dots = 392207, blackdots = 269888, whitedots = 161905, coffee
white dots = 161905, white r = 50, g = 37, b = 27
coffee avg expected color r = 160, g = 136, b = 109
: 82238.3, 21774.8, -25000, 9346.32, -8041.51, 1686.57
: -572.188, 528.503, 504.12, -615.942, -43.5291, -76.7206
: -7210.03, 412.317, -21236, -19049.4, 1503.78, -12852.1
: -998.655, -384.596, 984.81, -86.7882, -330.126, 666.503
: -2336, -901.431, -7822.18, -9859.23, 9768.21, 7115.86
dc : 0
multiplied avg : 8.25067e+07 원본(어두움)->YCbCr에서 밝기 수정 -> dct
mean : [-26.15159444234967]
stddev : [1372.109313500124]
image processing finished!
Web Server
^Cterminator sig = 2
root@am57xx-evm:~/gihwahong/web_physics# ./a.out
r : 498
center : 1104,534
dc : 0
multiplied avg : 1.22234e+08 원본(밝음) -> dct
channel num : 3
type : 16
before avg 0 : 187.752 avg 1 : 127.733 avg 2 : 123.005
after avg 0 : 169.752 avg 1 : 127.733 avg 2 : 123.005
total dots = 852576, coffee dots = 385825, blackdots = 277128, whitedots = 189623, coffee
white dots = 189623, white r = 42, g = 34, b = 29
coffee avg expected color r = 157, g = 134, b = 112
: 88235.5, 21377.7, -26674.8, 10838.7, -9672.12, 2381.14
: -2321.06, 186.845, 1316.07, -723.251, 403.07, 109.987
: -7805.93, 1031.52, -23530.1, -20145, 2385.48, -14377.4
: -1218.43, -540.038, 2191.26, 734.933, -1013.6, 760.629
: -1312.11, -861.477, -8039.14, -10748.2, 11674.4, 8083.47
dc : 0
multiplied avg : 9.48893e+07 원본(밝음)->YCbCr에서 밝기 수정 -> dct
mean : [-28.40810786370933]
stddev : [1464.312231634323]
image processing finished!
```


[PJ CBM : 진행 상황]

❑ DSP : Camera DCT

문제 상황 : 빛에 영향을 줄이고 보니 DCT 유의미 한 값 제거됨



커피 원두 특성 재점검

✓

-> 조명 위치 변경



샘플<1>

```
before avg 0 : 195.683 avg 1 : 125.309 avg 2 : 136.917
after avg 0 : 169.683 avg 1 : 125.309 avg 2 : 136.917
total dots = 841500, coffee dots = 1453, blackdots = 274048, whitedots = 565999, coffee avg 1st r = 187, g = 176, b = 112
white dots = 565999, white r = 29, g = 34, b = 45
coffee avg expected color r = 216, g = 210, b = 157
: 137161, 32572.2, -55800.8, 6934.64, -15824, -2988.49
: -58.5844, 216.823, 28.123, -241.913, 56.2409, -1.86411
: -32146.1, -4562.23, -16755.4, -23248.8, 11594.4, -9965.13
: -119.448, -176.586, -13.6443, -169.077, -107.248, 219.999
: -12125.2, -2853.32, 1950.2, -7452.29, 11716.5, 11124.6
dc : 0
multiplied avg : 2.65136e+08
mean : [-46.12706290641563]
stddev : [1887.351185984664]
```



샘플<9>

```
before avg 0 : 195.754 avg 1 : 126.434 avg 2 : 135.124
after avg 0 : 169.754 avg 1 : 126.434 avg 2 : 135.124
total dots = 834156, coffee dots = 638, blackdots = 272076, whitedots = 561442, coffee avg 1st r = 185, g = 172, b = 125
white dots = 561442, white r = 29, g = 35, b = 44
coffee avg expected color r = 214, g = 207, b = 169
: 136410, 32546.4, -55637.8, 6799.96, -15679.3, -3093.04
: 196.173, 298.019, -79.6971, -248.553, 12.5893, -32.3852
: -32085.7, -4608.02, -16486, -23155.1, 11559.1, -9786.43
: -75.2141, -157.905, -165.373, -285.087, -71.5193, 193.02
: -12099.8, -2865.47, 2041.34, -7339.84, 11572.1, 11112.6
dc : 0
multiplied avg : 2.63223e+08
mean : [-45.90363328947425]
stddev : [1878.807845347321]
```

[PJ CBM : 진행 상황]

☐ DSP : Camera

Lab 색상으로 커피 색상 비교

어두운 사진



```
./a.outroot@am57xx-evm:~/gihwahong/web_physics# ./a.out  
channel num : 3  
type : 16  
before avg 0 : 113.775 avg 1 : 124.494 avg 2 : 133.068  
after avg 0 : 167.688 avg 1 : 124.494 avg 2 : 133.068
```

밝은 사진



```
channel num : 3  
type : 16  
before avg 0 : 197.355 avg 1 : 125.096 avg 2 : 132.12  
after avg 0 : 169.355 avg 1 : 125.096 avg 2 : 132.12
```

결론 : 밝기에 따른 차이 ≤ 0.5

[PJ CBM : 진행 상황]

❑ DSP : Camera

Lab 색상 -> 커피색 SCAA (Specialty Coffee Association of America) 로 비교

색상표(RGB)

R	G	B
122	61	26
108	55	25
96	49	32
78	44	23
61	38	26
58	43	28
49	40	36
39	30	28



색상표(Lab)

L	A	B
83.9	151.97	160.04
74.9	148.89	156.98
66.9	147.03	148.97
55.9	141.1	147.99
44.9	136.98	140.95
48	132	140
43	131	132
31	132	130

밝기에 따른 차이 ≤ 0.5 적용가능

[PJ CBM : 진행 상황]

❑ DSP : Camera

원두 특성

기존 예상 특성



샘플<1>



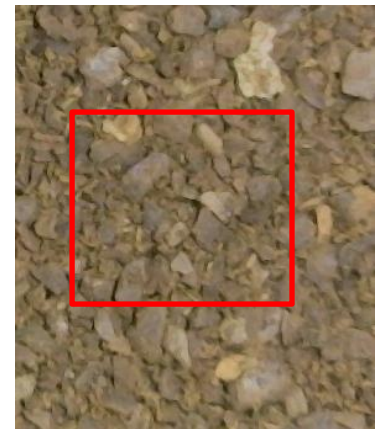
샘플<9>



실제 특성



샘플<1>



샘플<9>

샘플<9> : 알갱이 사이즈가 혼재

[PJ CBM : 진행 상황]

❑ DSP : Camera

원두 특성에 따른 원두 사이즈 특성 추출 방법

➡ 감마 처리

➡ 음영 픽셀 인식, 테스트



감마 수정

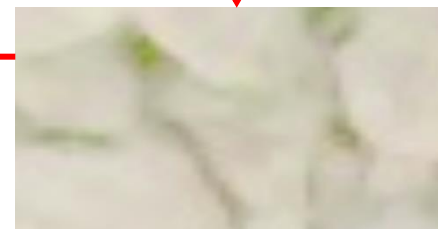


음영 인식

<최종 결과>

```
total dots = 852576, coffee dots = 4930, blackdots = 277128,  
white dots = 570518, white r = 33, g = 39, b = 49  
coffee avg expected color r = 213, g = 207, b = 178
```

샘플<1> coffee dots = 371 샘플<9> coffee dots = 4290



[PJ CBM : 진행 상황]

❑ DSP : Camera

원두 특성에 따른 이미지 추출 방법

➡ 측정시마다 값이 차이가 있음

➡ 여러번 측정해서 평균 + 알갱이 넓이 계산(Contour)방법으로 보조

샘플<1>

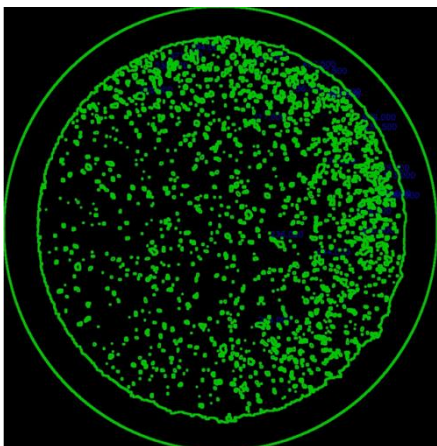


블러

라플라시안필터

<최종 결과>

contour(200~1000): 9



샘플<9>

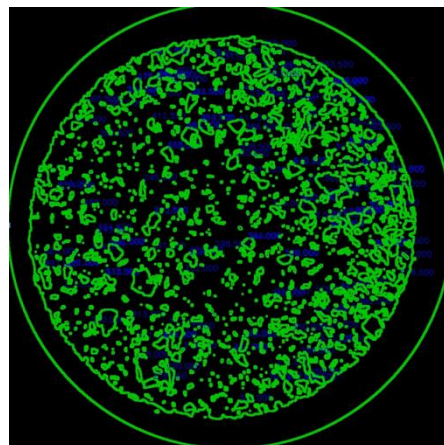


블러

라플라시안필터

<최종 결과>

contour(200~1000): 176



[PJ CBM : 진행 상황]

❑ 문제 : MCU FreeRTOS(UDP + Peripheral) 프로젝트 통합시 무게 센서 인식 불가

< 해결 >

- 세마포어 처리
- 통신 주기 짧게 수정(datasheet)
- 코드 위치 변경

< 변경 전 >

코드 위치 : het pwm interrupt

```

gioSetBit(hetPORT1,18,1);
gioSetBit(hetPORT1,2,0);
while(gioGetBit(hetPORT1,18));

wait(3);

for(i=0;i<24;i++){
    gioSetBit(hetPORT1,2,1);
    count=count<<1;
    wait_us(50);        //1us
    gioSetBit(hetPORT1,2,0);
    wait_us(50);
    if(gioGetBit(hetPORT1,18)) count++;
}

gioSetBit(hetPORT1,2,1);
wait_us(50);
count=count^0x800000;
weight=count;
gioSetBit(hetPORT1,2,0);
    
```

<통신 주기 수정 위한 datasheet 확인>

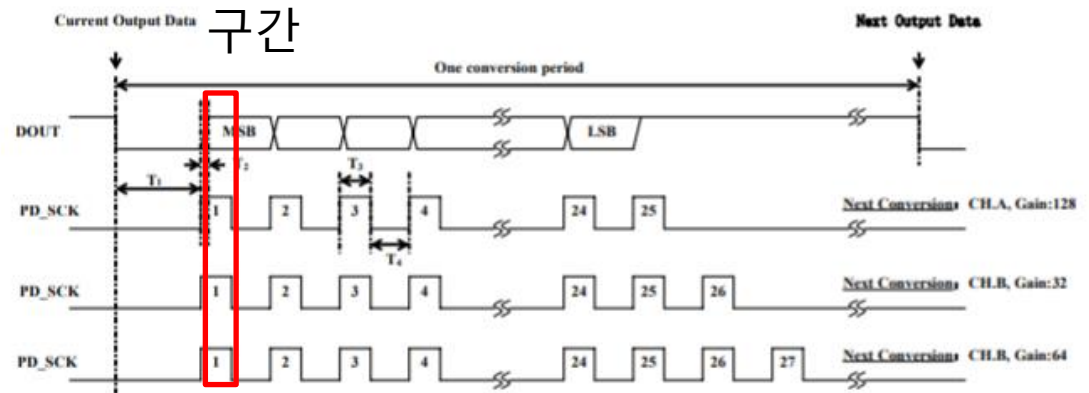


Fig.2 Data output, input and gain selection timing and control

Symbol	Note	MIN	TYP	MAX	Unit
T ₁	DOUT falling edge to PD_SCK rising edge	0.1			μs
T ₂	PD_SCK rising edge to DOUT data ready			0.1	μs
T ₃	PD_SCK high time	0.2	1	50	μs
T ₄	PD_SCK low time	0.2	1		μs

구간 제한

[PJ CBM : 진행 상황]

❑ 문제 : MCU FreeRTOS(UDP + Peripheral) 프로젝트 통합시 무게 센서 인식 불가

< 해결 >

- 세마포어 처리
- 통신 주기 짧게 수정(datasheet)
- 코드 위치 변경

< 변경 전 >

코드 위치 : het pwm interrupt

```
gioSetBit(hetPORT1,18,1);
gioSetBit(hetPORT1,2,0);
while(gioGetBit(hetPORT1,18));

wait(3);

for(i=0;i<24;i++){
    gioSetBit(hetPORT1,2,1);
    count=count<<1;
    wait_us(50);        //1us
    gioSetBit(hetPORT1,2,0);
    wait_us(50);
    if(gioGetBit(hetPORT1,18)) count++;
}

gioSetBit(hetPORT1,2,1);
wait_us(50);
count=count^0x800000;
weight=count;
gioSetBit(hetPORT1,2,0);
```

< 변경 후 >

코드 위치 : task

```
if(xSemaphoreTake(sem1, (TickType_t)0x01)==pdTRUE){ 세마포어
    gioSetBit(hetPORT1,18,1);
    gioSetBit(hetPORT1,2,0);
    if(gioGetBit(hetPORT1,18)==0){

        wait(3);

        for(i=0;i<24;i++){ 타이머 변경(자원 동시 사용 제한)
            gioSetBit(hetPORT1,2,1);
            count=count<<1;
            wait(4);        //1us
            gioSetBit(hetPORT1,2,0);
            wait(4);
            if(gioGetBit(hetPORT1,18)) count++;
        }

        gioSetBit(hetPORT1,2,1);
        wait_us(4);
        count=count^0x800000;
        weight=count;
        gioSetBit(hetPORT1,2,0);
    }
}

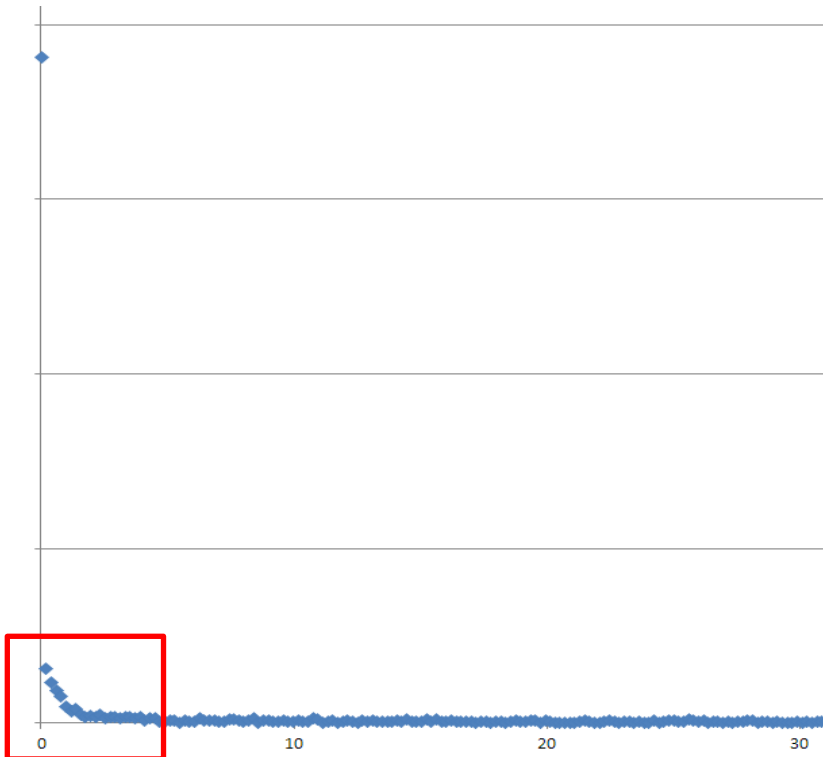
xSemaphoreGive(sem1);
}
```


[PJ CBM : 진행 상황]

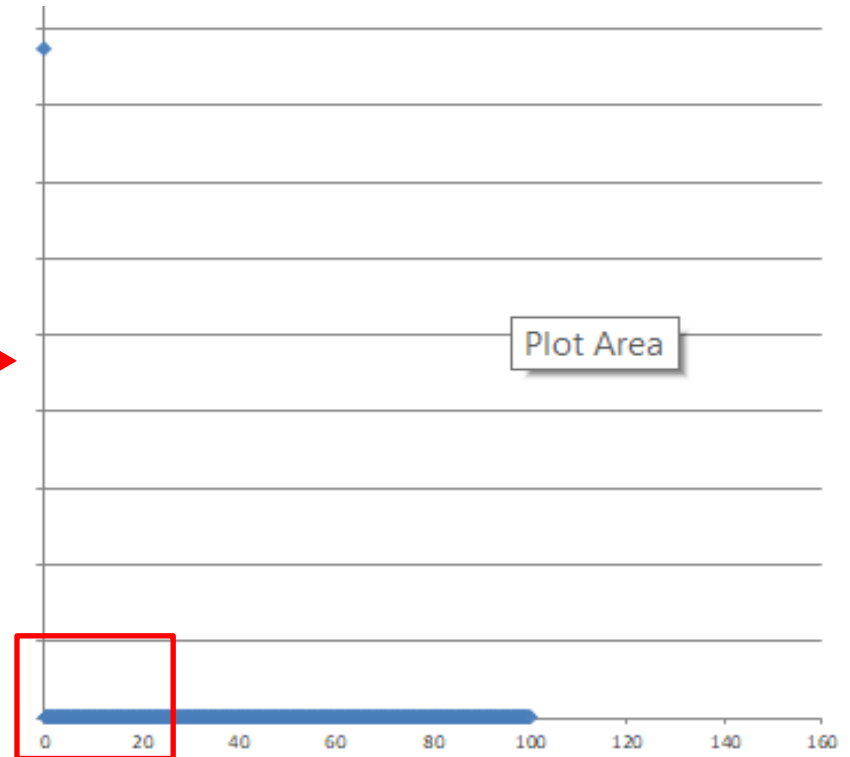
□ 디지털 필터 적용

- 무게 센서 문제 해결 -> 디지털 필터 적용 (1차 필터) -> 푸리에 주파수 분석

< 적용 전 >




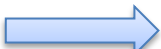





< 적용 후 >



[프로젝트 일정]

7/5~7/11

-  DSP(Camera)
-  Sensor fix(고장 수리)
-  Digital Filter
-  WebGL
-  Integration
-  Debug
-  Communication(dsp<->mcu)

