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22BCT0046

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LABORATORY ASSIGNMEN-2

PROBLEM STATEMENT

In a remote wildlife conservation area, monitoring animal movements and detecting potential fires is crucial for ecological balance and safety. Our system utilizes:-

- Active Infrared (AFIR) sensors to track wildlife movement.
- Charge Coupled Device (CCD) thermal sensors to detect early-stage fires.

The goal is to implement an automated monitoring system that identifies animal population, prevents poaching, and enables early wildfire detection.

Significance and Real World Application

Wildlife :- protecting endangered species by monitoring movement patterns.
preventing illegal poaching of endangered animals by hunters
logging activities can be stopped.

Forest Fire :- early wildfire detection to minimize damage and ensure rapid response during disaster and relief management.

Problem Analysis with Numerical Example

We simulate three types of sensor with varying accuracy and drift rates over time.

Sensor Characteristics

Sensor Type	Formula	Accuracy Error	Annual Drift
AFIR	$P_{out} = P_{in} \times e^{-\alpha d}$	$\pm$ 1W	0.6%
CCD	$V = q \times N / C$	$\pm$ 1.5V	0.6%

① AFIR Active Infrared Sensor

$P_{out} = P_{in} \cdot e^{-\alpha d}$

P_{in} = initial power in W

e = euler's number = 2.71828

α = attenuation coefficient

d = distance radiation travels throughout

Sensitivity $S = \Delta P_{out} / \Delta d$

Resolution $R = 1/S$

Threshold condition $P_{threshold} > P_{output}$ Detected

$P_{in} = 5W$ $\alpha = 0.1$ $d = 3m$ $P_{threshold} = 6W$

$P_{out} = 5 \times e^{-0.1 \times 3} = 3.704W$

Object Missing

② CCD sensor

$V = \frac{q \times N}{C}$

$q = 1.6 \times 10^{-19} C$

N = number of photo generated electrons

C = capacitance of CCD (F)

$N = 10^7$ $C = 2 \times 10^{-12} F$

$V = \frac{(1.6 \times 10^{-19}) \times (5 \times 10^6)}{(1.2 \times 10^{-12})} \Rightarrow V = 0.67V$

Temperature is recorded at 50°C

$Temp_{Kelvin} = 50 + 273 = 323K.$

Voltage calculation:-

$V = IR$

$I = P_m \times R_o$

$P_m = \sigma \cdot e \cdot A \cdot T^4$

σ – Boltzman constant $5.67 \times 10^{-8} Wm^{-2}$

e – emissivity 0.95

A – area $1m^2$

R_o – responsivity $0.01 AW^{-1}$

R – resistance 1000Ω

I – photocurrent

V – Voltage

$P_{in} = \sigma \cdot e \cdot A \cdot T^4 = 5.67 \times 10^{-8} \cdot 0.95 \cdot 1 \cdot (323)^4$

$= 586.29W$

$I_p = P_m \times R_o = 586.29 \times 0.01 = 5.8629 A$

$V = I \times R = 5862.95 V$

Control Logic

CCD Sensor:-

Detects sudden temperature increase to trigger an alarm, alert gets generated if temp raises from 45°C to 65°C.

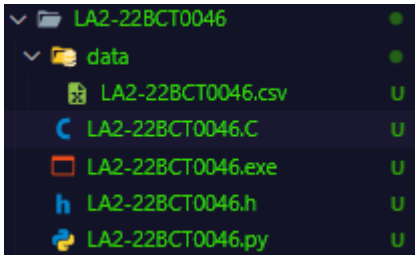
AFIR Sensors:-

Detects heat signature of animals & logs their movements.

Pseudocode

```
BEGIN
    Start AFIR, CCD sensors.
    Initialize random generator for sensor simulation
    Open CSV file for output.
    Initialize animals in grid

    For 50 iterations
        print each step in csv file.
        #CCD Simulation for fire detection
        For each grid coord (x, y) DO:-
            temp between 30-70°C
            if temp > threshold i.e 60°C
                print FIRE at x, y index, temp.
            V = σ · ε · A · T⁴    A → of x, y
            print Voltage too.
        END IF
    ENDFOR

    #AFIR Sensor for wildlife tracking
    For each animal do:-
        track animal position and heat signature
        print Animal id x y coord & heat
    ENDFOR
    Sleep (1) ; //Simulate real time updates

    Plot animal locations & fire points on grid.
    Show trail of animal movement.

END
```

Folder Structure:



Sensors and Animal Definition:

```c
typedef struct {
    int id;
    char type[20];
    float last_value;
} CCDSensor;
```

```c
typedef struct {
    int id;
    char type[20];
    float last_value;
} AFIRSensor;
```

```c
void init_afir(AFIRSensor *sensor, int id) {
    sensor->id = id;
    snprintf(sensor->type, sizeof(sensor->type), "AFIR");
    sensor->last_value = 0.0;
}
void init_ccd(CCDSensor *sensor, int id) {
    sensor->id = id;
    snprintf(sensor->type, sizeof(sensor->type), "CCD");
    sensor->last_value = 0.0;
}
```

```c
typedef struct {
    int id;
    float x, y;
    float heat_signature;
} Animal;
```

CSV Output

```c
    FILE *file = fopen("data/LA2-22BCT0046.csv", "w");
    if (!file) {
        perror("Error: Could not create LA2-22BCT0046.csv");
        return EXIT_FAILURE;
    }
    fclose(file);
```

```c
  for (int i = 0; i < NUM_ANIMALS; i++) {
      track_animal(&animals[i]);
      fprintf(file, "ANIMAL %d %.1f %.1f %.1f\n", animals[i].id, animals[i].x, animals[i].y, animals[i].heat_signature);
  }

  fclose(file);
  sleep(1);
```

TestCase:-

1.

```
f:\sensorsLabLA1\LA2-22BCT0046>cd "f:\sensorsLabLA1\LA2-22BCT0046\" && gcc LA2-22BCT0046.C -o LA2-22BCT0046 && "f:\sensorsLabLA1\LA2-22BCT0046\"LA2-22BCT0046
Starting simulation...
Enter the number of simulation steps: 10
Enter area in m^2: 10
Enter responsivity: 0.04
Enter resistance: 10
Enter emissivity: 0.1
Step 0 completed....
Step 1 completed....
Step 2 completed....
Step 3 completed....
Step 4 completed....
Step 5 completed....
Step 6 completed....
Step 7 completed....
Step 8 completed....
Step 9 completed....
Data successfully saved to LA2-22BCT0046.csv

f:\sensorsLabLA1\LA2-22BCT0046>
```

CSV File

LA2-22BCT0046.C U | LA2-22BCT0046.csv U

LA2-22BCT0046 > data > LA2-22BCT0046.csv

```
STEP 0
FIRE 0 4 70.00 VOLTAGE 0.28
FIRE 0 9 60.00 VOLTAGE 0.24
FIRE 1 0 70.00 VOLTAGE 0.28
FIRE 1 2 64.00 VOLTAGE 0.26
FIRE 2 0 68.00 VOLTAGE 0.27
FIRE 2 1 63.00 VOLTAGE 0.25
FIRE 2 2 60.00 VOLTAGE 0.24
FIRE 2 8 61.00 VOLTAGE 0.24
FIRE 3 5 64.00 VOLTAGE 0.26
FIRE 3 6 68.00 VOLTAGE 0.27
FIRE 4 1 66.00 VOLTAGE 0.26
FIRE 4 2 61.00 VOLTAGE 0.24
FIRE 4 3 62.00 VOLTAGE 0.25
FIRE 5 0 67.00 VOLTAGE 0.27
FIRE 5 2 70.00 VOLTAGE 0.28
FIRE 5 4 66.00 VOLTAGE 0.26
FIRE 5 5 66.00 VOLTAGE 0.26
FIRE 5 6 61.00 VOLTAGE 0.24
FIRE 6 1 67.00 VOLTAGE 0.27
FIRE 7 2 68.00 VOLTAGE 0.27
FIRE 8 2 64.00 VOLTAGE 0.26
FIRE 8 7 60.00 VOLTAGE 0.24
FIRE 9 3 64.00 VOLTAGE 0.26
ANIMAL 1 7.0 4.0 39.0
ANIMAL 2 0.0 4.0 40.0
ANIMAL 3 5.0 9.0 35.0
ANIMAL 4 8.0 4.0 39.0
ANIMAL 5 8.0 2.0 36.0
STEP 1
FIRE 0 1 68.00 VOLTAGE 0.27
FIRE 0 9 65.00 VOLTAGE 0.26
FIRE 1 1 66.00 VOLTAGE 0.26
FIRE 1 4 68.00 VOLTAGE 0.27
FIRE 2 1 61.00 VOLTAGE 0.24
FIRE 2 3 66.00 VOLTAGE 0.26
FIRE 2 5 64.00 VOLTAGE 0.26
FIRE 2 6 65.00 VOLTAGE 0.26
FIRE 2 8 69.00 VOLTAGE 0.28
FIRE 3 1 67.00 VOLTAGE 0.27
FIRE 3 2 64.00 VOLTAGE 0.26
FIRE 3 3 69.00 VOLTAGE 0.28
FIRE 3 9 64.00 VOLTAGE 0.26
FIRE 4 8 68.00 VOLTAGE 0.27
FIRE 5 4 64.00 VOLTAGE 0.26
FIRE 5 9 64.00 VOLTAGE 0.26
FIRE 6 2 62.00 VOLTAGE 0.25
FIRE 6 3 60.00 VOLTAGE 0.24
FIRE 6 4 70.00 VOLTAGE 0.28
FIRE 6 7 67.00 VOLTAGE 0.27
FIRE 7 4 63.00 VOLTAGE 0.25
FIRE 7 5 68.00 VOLTAGE 0.27
FIRE 7 7 63.00 VOLTAGE 0.25
FIRE 9 9 67.00 VOLTAGE 0.27
ANIMAL 1 7.0 3.0 39.0
ANIMAL 2 0.0 4.0 37.0
ANIMAL 3 4.0 9.0 40.0
ANIMAL 4 7.0 4.0 40.0
ANIMAL 5 8.0 3.0 36.0
```

2.

```
f:\sensorsLabLA1\LA2-22BCT0046>cd "f:\sensorsLabLA1\LA2-22BCT0046\" && gcc LA2-22BCT0046.C -o LA2-22BCT0046 && "f:\sensorsLabLA1\LA2-22BCT0046\"LA2-22BCT0046
Starting simulation...
Enter the number of simulation steps: 20
Enter area in m^2: 1000
Enter responsivity: 0.1
Enter resistance: 10
Enter emissivity: 0.3
Step 0 completed....
Step 1 completed....
Step 2 completed....
Step 3 completed....
Step 4 completed....
Step 5 completed....
Step 6 completed....
Step 7 completed....
Step 8 completed....
Step 9 completed....
Step 10 completed....
Step 11 completed....
Step 12 completed....
Step 13 completed....
Step 14 completed....
```

CSV File

LA2-22BCT0046.C U | LA2-22BCT0046.csv U

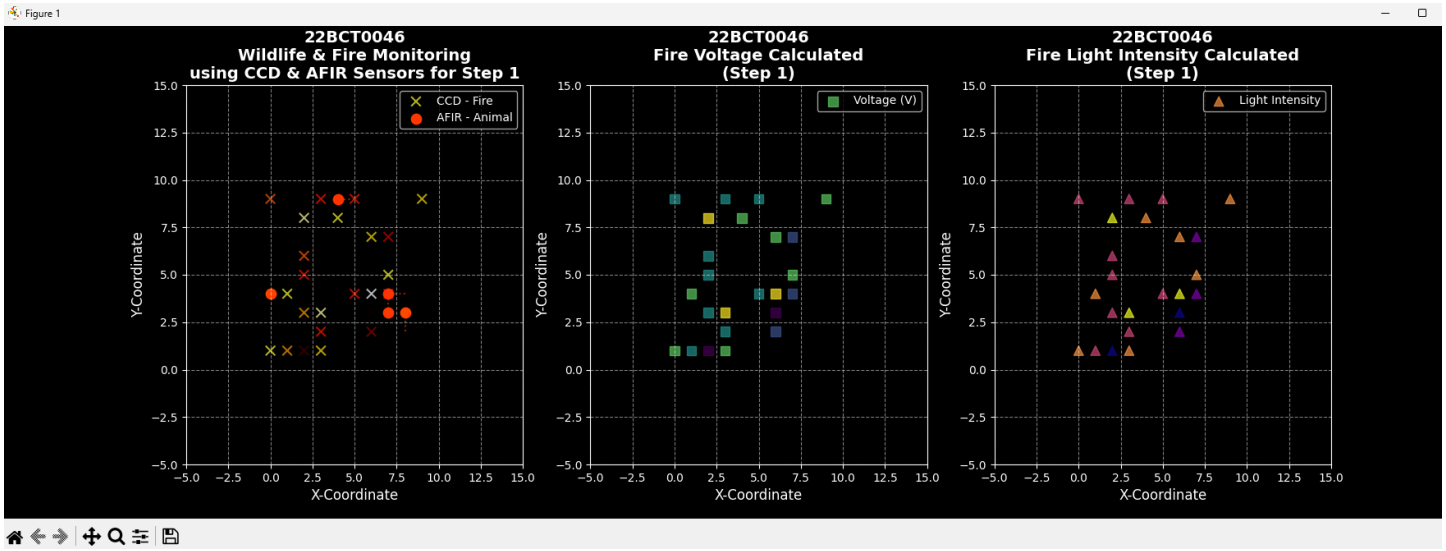
LA2-22BCT0046 > data > LA2-22BCT0046.csv

```
STEP 0
FIRE 0 2 64.00 VOLTAGE 192.00
FIRE 0 7 67.00 VOLTAGE 201.00
FIRE 1 1 67.00 VOLTAGE 201.00
FIRE 2 1 70.00 VOLTAGE 210.00
FIRE 2 2 67.00 VOLTAGE 201.00
FIRE 2 5 70.00 VOLTAGE 210.00
FIRE 2 8 64.00 VOLTAGE 192.00
FIRE 3 0 62.00 VOLTAGE 186.00
FIRE 3 1 68.00 VOLTAGE 204.00
FIRE 3 4 60.00 VOLTAGE 180.00
FIRE 5 2 68.00 VOLTAGE 204.00
FIRE 5 4 61.00 VOLTAGE 183.00
FIRE 6 0 66.00 VOLTAGE 198.00
FIRE 6 6 68.00 VOLTAGE 204.00
FIRE 6 8 64.00 VOLTAGE 192.00
FIRE 7 0 64.00 VOLTAGE 192.00
FIRE 7 6 65.00 VOLTAGE 195.00
FIRE 7 7 67.00 VOLTAGE 201.00
FIRE 7 9 65.00 VOLTAGE 195.00
FIRE 8 0 61.00 VOLTAGE 183.00
FIRE 8 2 62.00 VOLTAGE 186.00
FIRE 8 3 61.00 VOLTAGE 183.00
FIRE 9 8 62.00 VOLTAGE 186.00
ANIMAL 1 6.0 5.0 39.0
ANIMAL 2 6.0 0.0 36.0
ANIMAL 3 6.0 6.0 38.0
ANIMAL 4 8.0 3.0 39.0
ANIMAL 5 4.0 2.0 35.0
STEP 1
FIRE 0 1 61.00 VOLTAGE 183.00
FIRE 0 4 65.00 VOLTAGE 195.00
FIRE 0 5 60.00 VOLTAGE 180.00
FIRE 0 6 65.00 VOLTAGE 195.00
FIRE 0 9 65.00 VOLTAGE 195.00
FIRE 1 7 61.00 VOLTAGE 183.00
FIRE 1 9 69.00 VOLTAGE 207.00
FIRE 2 1 65.00 VOLTAGE 195.00
FIRE 2 5 68.00 VOLTAGE 204.00
FIRE 2 8 70.00 VOLTAGE 210.00
FIRE 2 9 70.00 VOLTAGE 210.00
FIRE 3 0 67.00 VOLTAGE 201.00
FIRE 3 4 60.00 VOLTAGE 180.00
FIRE 3 7 67.00 VOLTAGE 201.00
FIRE 3 8 70.00 VOLTAGE 210.00
FIRE 4 2 62.00 VOLTAGE 186.00
FIRE 4 9 68.00 VOLTAGE 204.00
FIRE 5 1 64.00 VOLTAGE 192.00
FIRE 5 3 68.00 VOLTAGE 204.00
FIRE 5 4 61.00 VOLTAGE 183.00
FIRE 6 1 65.00 VOLTAGE 195.00
FIRE 6 5 66.00 VOLTAGE 198.00
FIRE 6 8 70.00 VOLTAGE 210.00
FIRE 6 9 65.00 VOLTAGE 195.00
FIRE 7 1 69.00 VOLTAGE 207.00
FIRE 7 6 69.00 VOLTAGE 207.00
FIRE 8 0 62.00 VOLTAGE 186.00
FIRE 8 7 64.00 VOLTAGE 192.00
ANIMAL 1 5.0 6.0 40.0
```

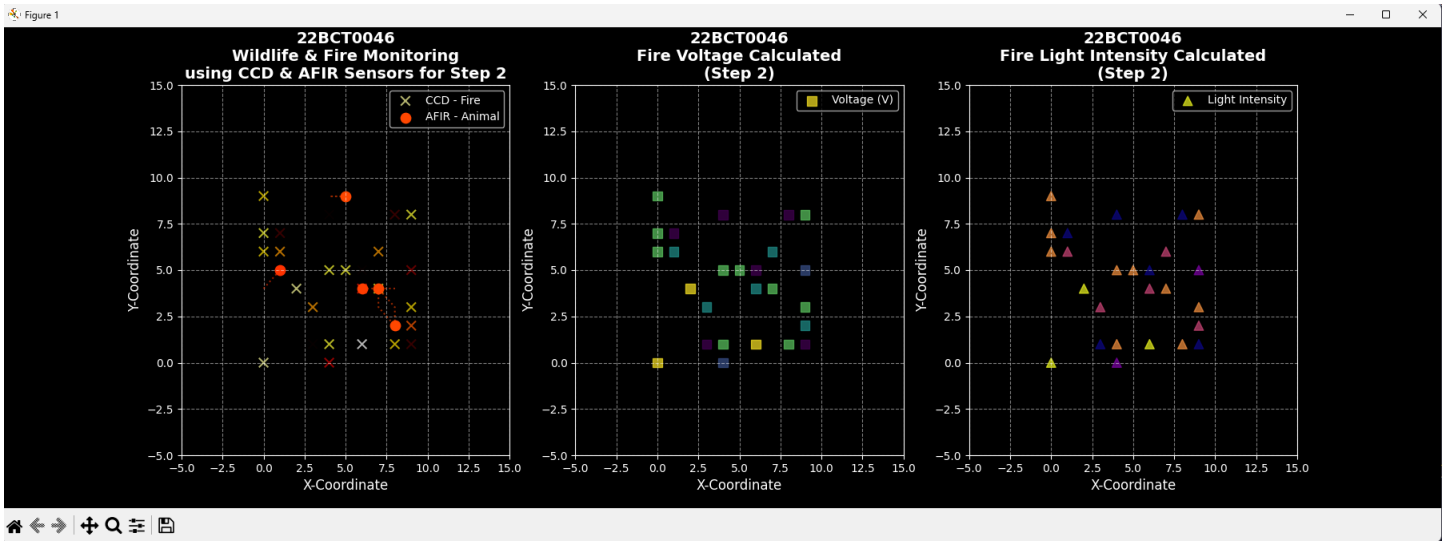
OUTPUT:

TestCase1;

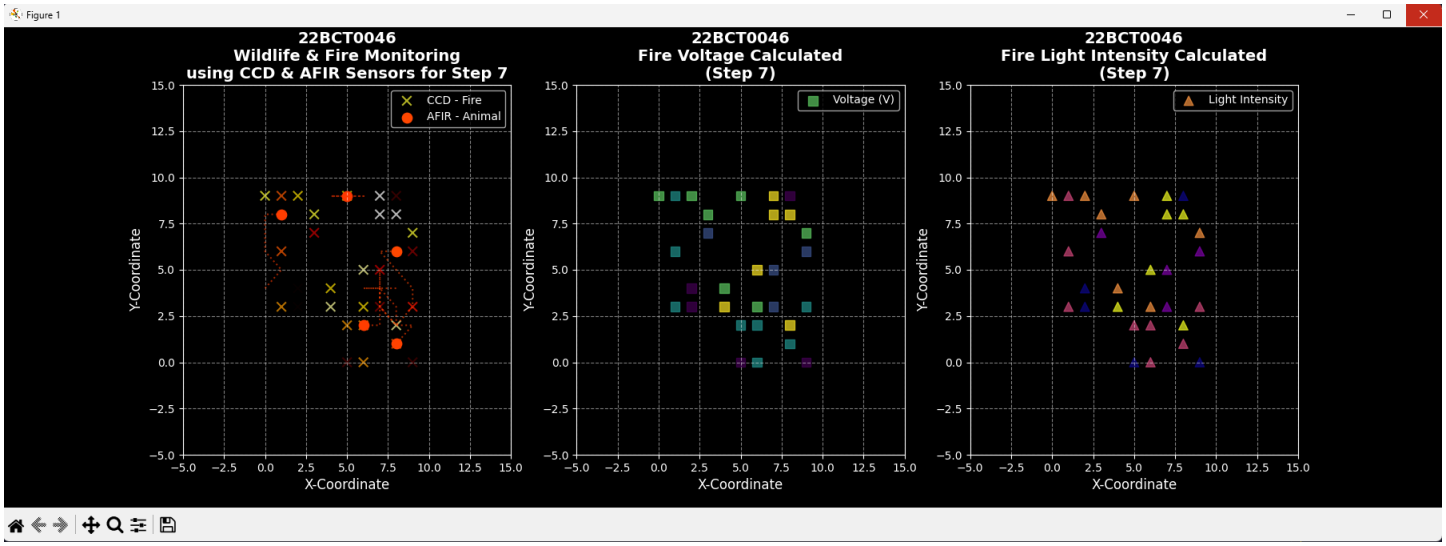
Step1:



Step2;

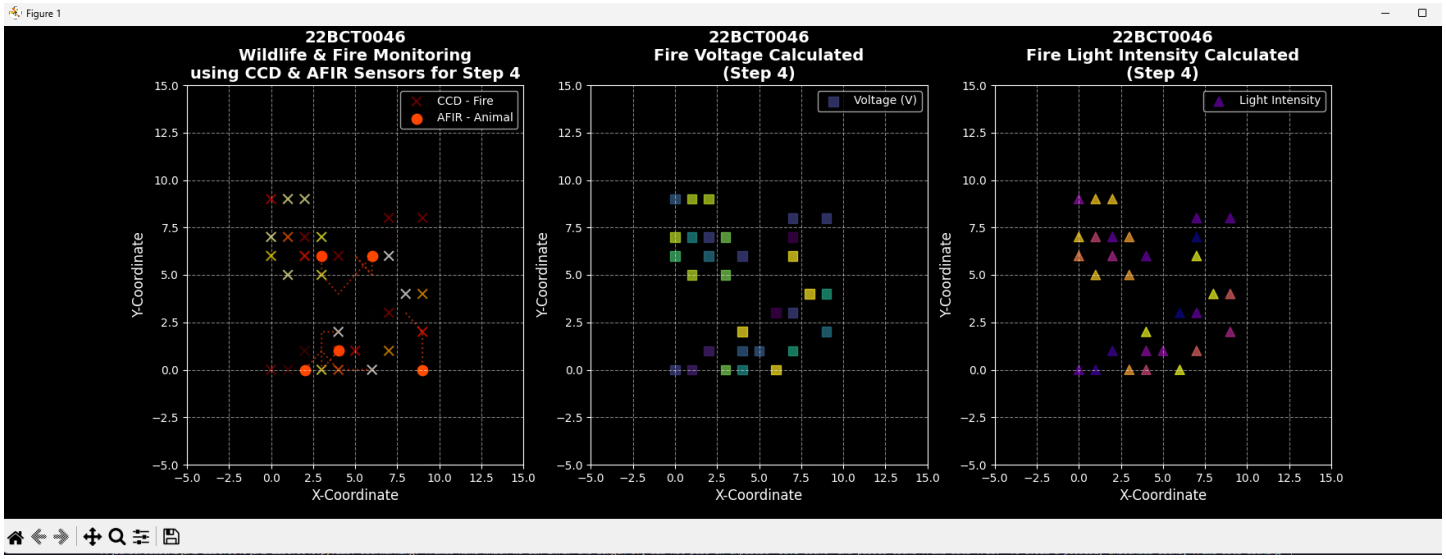


Step7

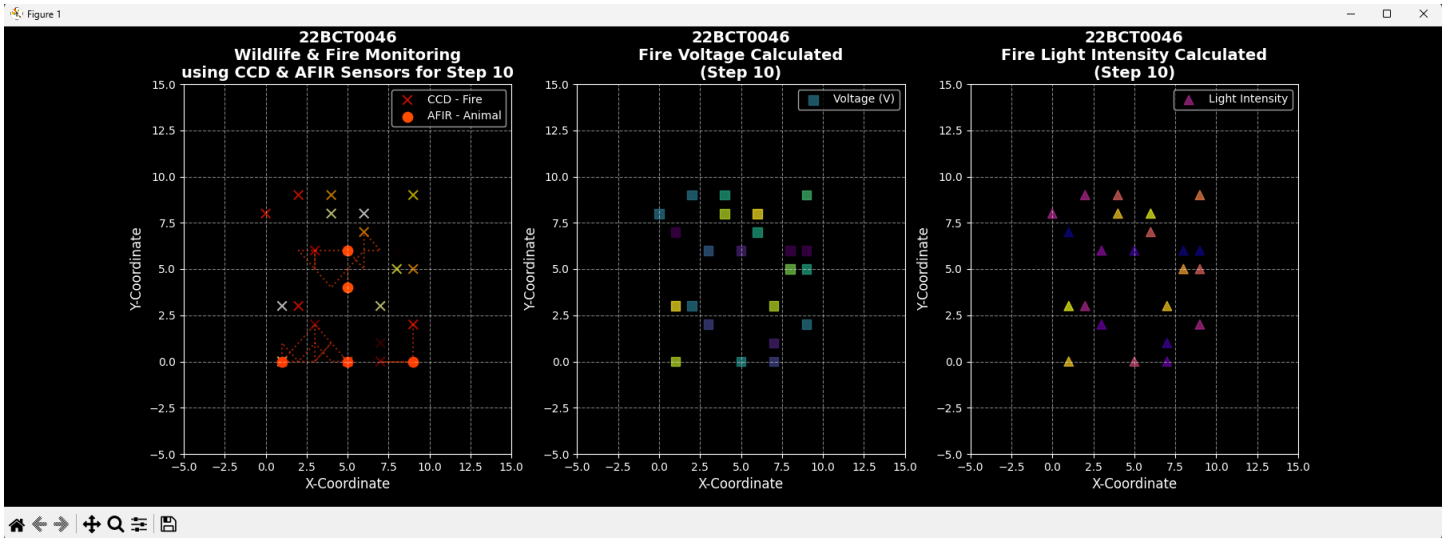


TestCase2:

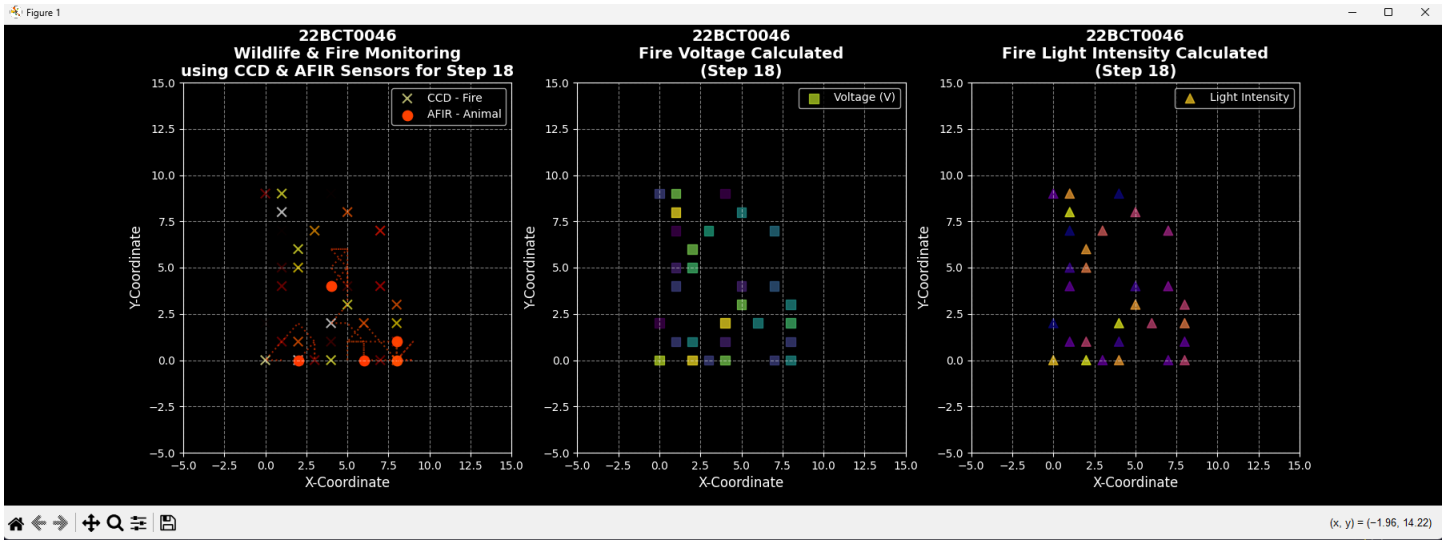
Step4:



Step 10:



Step 18:



Results and Analysis

Observed Trends:-

Animal tracking:- It reveals movements pattern over time. Trails dots indicate path of each animal.

Fires in wild:- Whenever temperature is more than threshold, voltage and current varies over temperature.

CCD sensor makes early detection of wildfire by checking sudden temperature increase. But there may be drift in sensor due to age, and decreased sensor accuracy due to environment condition.

AFIR sensors tracks animal sensitivity heat signatures effectively, but readings might have small errors due to animal movement and Temperature still are effective in monitoring wildlife activity.