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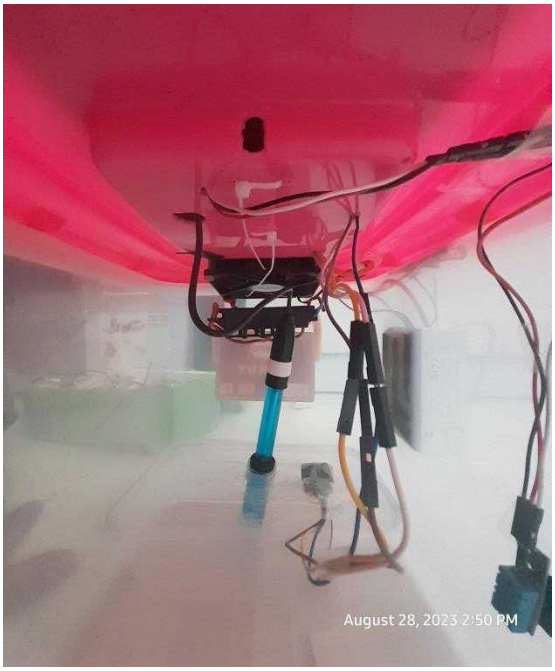
LAMPIRAN

Lampiran 1 Dokumentasi alat



Lampiran 2 Pengerjaan alat dan kalibrasi sensor

Lampiran 3 Pembuatan tape dan pengambilan data

Lampiran 4 Program pengujian sensor pH

```
const int ph_Pin = A0;
float Po = 0;
float PH_step;
int nilai_analog_PH;
double TeganganPh;

//untuk kalibrasi
float PH4=3.84;
float PH7=3.48;

void setup() {
  pinMode (ph_Pin, INPUT);
  Serial.begin(9600);
}

void loop() {
 nilai_analog_PH = analogRead(ph_Pin);
 Serial.print("Nilai ADC pH: ");
 Serial.println(nilai_analog_PH);
 TeganganPh = 5/1024.0 * nilai_analog_PH;
 Serial.print("Tegangan PH: ");
 Serial.println(TeganganPh, 3);

 PH_step = (PH4 - PH7)/3;
 Po = 7.00 + ((PH7 - TeganganPh)/(PH_step));
//Po = 7.00 + ((teganganPh7 - TeganganPh) / PhStep);
 Serial.print("Nilai PH cairan: ");
 Serial.println (Po, 2);
 delay (3000);
 }
```

Lampiran 5 Program pengujian sensor alkohol

```
const int analogPin = A0; // Pin analog untuk membaca tegangan sensor
float slope = 19.539;    // Koefisien kemiringan (slope) dari persamaan regresi
float intercept = -30.794; // Intersep dari persamaan regresi linier

void setup() {
  Serial.begin(9600); // Inisialisasi komunikasi serial
}

void loop() {
  // Baca nilai tegangan dari sensor
  int sensorValue = analogRead(analogPin);
  float voltage = sensorValue * (5.0 / 1023.0);
  float alcoholConcentration = (voltage * slope + intercept);  // Mengubah hasil
menjadi dalam bentuk persentase

  // Cetak hasil ke Serial Monitor
  Serial.print("Nilai Tegangan: ");
  Serial.print(voltage);
  Serial.print(" | Konsentrasi Alkohol: ");
  Serial.print(alcoholConcentration);
  Serial.println(" %");
  delay(30000);
}
```

Lampiran 6 Program pengujian sensor suhu

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>

#define DHT_PIN 7
DHT dht(DHT_PIN, DHT11);

class DHTSensor {
private:
  float temperature;
public:
  void readSensorData() {
    temperature = dht.readTemperature();
}

  float getTemperature() {
    return temperature;}
};

DHTSensor dhtSensor;

// Inisialisasi LCD I2C dengan alamat 0x27 (sesuaikan jika berbeda)
LiquidCrystal_I2C lcd(0x27, 16, 2); // Alamat 0x27, 16 kolom, 2 baris

void setup() {
  lcd.begin();      // Inisialisasi LCD
  lcd.backlight();  // Nyalakan backlight LCD
  lcd.setCursor(0, 0);
  lcd.print("Temp: ");

  Serial.begin(9600);
  dht.begin();
}

void loop() {
  dhtSensor.readSensorData();

  Serial.print(" %, Temperature: ");
  Serial.print(dhtSensor.getTemperature());
  Serial.println(" °C");

  lcd.setCursor(6, 0);
                :(dhtSensor.getTemperature());
                :(" C ");

                )00);}
```

Lampiran 7 Program pengujian aktuator suhu

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>

// Deklarasi pin untuk mengendalikan relay
const int heaterRelayPin = 2;
const int fanRelayPin = 3;
const int buzzerPin = 8; // Pin buzzer

// Konfigurasi sensor DHT11
#define DHTPIN 7  // Pin tempat sensor DHT11 dihubungkan
#define DHTTYPE DHT11 // Tipe sensor DHT

DHT dht(DHTPIN, DHTTYPE);

// Konfigurasi LCD I2C
LiquidCrystal_I2C lcd(0x27, 20, 4);  // Alamat I2C, jumlah kolom, dan baris

// Status heater dan kipas
bool heaterOn = false;
bool fanOn = false;

unsigned long previousMillis = 0; // Waktu terakhir bacaan
const unsigned long interval = 6000;

void setup() {
  // Inisialisasi sensor DHT
  dht.begin();

  // Inisialisasi LCD
  lcd.begin();
  lcd.backlight();
  lcd.clear();

  // Set pin sebagai output untuk relay dan buzzer
  pinMode(heaterRelayPin, OUTPUT);
  pinMode(fanRelayPin, OUTPUT);
  pinMode(buzzerPin, OUTPUT);

  // Matikan heater dan kipas saat awal
  digitalWrite(heaterRelayPin, HIGH);
  digitalWrite(fanRelayPin, HIGH);
  /rite(buzzerPin, LOW); // Matikan buzzer



() {
1 long currentMillis = millis(); // Waktu sekarang
```

```
  // Periksa apakah sudah mencapai interval
  if (currentMillis - previousMillis >= interval) {
    previousMillis = currentMillis; // Update waktu terakhir bacaan

    // Bunyikan buzzer sekali
    digitalWrite(buzzerPin, HIGH);
    delay(100);
    digitalWrite(buzzerPin, LOW);
  }

  // Baca suhu dari sensor DHT11
  float temperature = dht.readTemperature();

  // Tampilkan suhu pada LCD
  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print(" C");

  // Tampilkan status heater pada LCD
  lcd.setCursor(0, 1);
  lcd.print("Heater: ");
  lcd.print(heaterOn ? "ON " : "OFF ");

  // Tampilkan status kipas pada LCD
  lcd.setCursor(0, 2);
  lcd.print("Fan: ");
  lcd.print(fanOn ? "ON " : "OFF ");

  // Kontrol heater  dan kipas berdasarkan perintah
  digitalWrite(heaterRelayPin, heaterOn);
  digitalWrite(fanRelayPin, !fanOn);
}
```

Lampiran 8 Program integrasi sistem

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include "AlcoholSensor.h"
#include "DFRobot_PH.h"
#include <EEPROM.h>
#include <DHT.h>
#include "HeaterFanController.h"
#include <Fuzzy.h>

#define DHTPIN 7        // Pin data sensor DHT11 terhubung ke pin 2
#define DHTTYPE DHT11   // Tipe sensor DHT yang digunakan
#define PH_PIN A1
DFRobot_PH ph;
DHT dht(DHTPIN, DHTTYPE);  // Inisialisasi objek DHT
const int heaterRelayPin = 2;
const int fanRelayPin = 3;
const int dhtPin = 7; // Pin untuk sensor DHT11

LiquidCrystal_I2C lcd(0x27, 20, 4);  // Alamat I2C dan ukuran LCD 2004
AlcoholSensor alcoholSensor(A0);
HeaterFanController controller(heaterRelayPin, fanRelayPin);

// Fuzzifikasi
Fuzzy *fuzzy = new Fuzzy();

// FuzzyInput for alcohol
FuzzySet *alcoholLow = new FuzzySet(0, 0, 8.63, 12.69);
FuzzySet *alcoholMedium = new FuzzySet(12, 13.48, 13.48, 15);
FuzzySet *alcoholHigh = new FuzzySet(14 16.1, 17, 17);

// FuzzyInput for acidity
FuzzySet *acidityLow = new FuzzySet(2.8, 4, 6, 6);
FuzzySet *acidityModerate = new FuzzySet(2.5, 2.75, 2.75, 3);
FuzzySet *acidityHigh = new FuzzySet(0, 0, 1.37, 2.7);

// FuzzyOutput for tape quality
FuzzySet *immatureQuality = new FuzzySet(0, 0, 2.5, 4);
FuzzySet *almostRipeQuality = new FuzzySet(3, 4.5, 4.5, 6);
FuzzySet *ripeQuality = new FuzzySet(5, 6.5, 6.5, 8);
FuzzySet *overRipeQuality = new FuzzySet(7, 8.5, 10, 10);
int buzzerPin = 8; // Pin buzzer
unsigned long previousMillis = 0;
          g interval = 5000; // Interval pembacaan 5 detik

          p() {
          isasi LCD
          n();
```

```
lcd.backlight();
// Inisialisasi komunikasi serial
Serial.begin(9600);
alcoholSensor.begin();
Inisialisasi pH Sensor
ph.begin();
dht.begin();
controller.begin();

// Set a random seed
randomSeed(analogRead(0));

// FuzzyInput for alcohol
FuzzyInput *alcoholLevel = new FuzzyInput(1);

alcoholLevel->addFuzzySet(alcoholLow);
alcoholLevel->addFuzzySet(alcoholMedium);
alcoholLevel->addFuzzySet(alcoholHigh);
fuzzy->addFuzzyInput(alcoholLevel);

// FuzzyInput for acidity
FuzzyInput *acidityLevel = new FuzzyInput(2);

acidityLevel->addFuzzySet(aciditylow);
acidityLevel->addFuzzySet(acidityModerate);
acidityLevel->addFuzzySet(acidityHigh);
fuzzy->addFuzzyInput(acidityLevel);

// FuzzyOutput for tape quality
FuzzyOutput *tapeQuality = new FuzzyOutput(1);

tapeQuality->addFuzzySet(immatureQuality);
tapeQuality->addFuzzySet(almostRipeQuality);
tapeQuality->addFuzzySet(ripeQuality);
tapeQuality->addFuzzySet(overRipeQuality);
fuzzy->addFuzzyOutput(tapeQuality);

// Building FuzzyRule
FuzzyRuleAntecedent *rule1Antecedent = new FuzzyRuleAntecedent();
rule1Antecedent->joinWithAND(alcoholLow, aciditylow);

FuzzyRuleConsequent *rule1Consequent = new FuzzyRuleConsequent();
rule1Consequent->addOutput(immatureQuality);

ıle *fuzzyRule1 = new FuzzyRule(1, rule1Antecedent, rule1Consequent);
ıddFuzzyRule(fuzzyRule1);

ng FuzzyRule
```

```
FuzzyRuleAntecedent *rule2Antecedent = new FuzzyRuleAntecedent();
rule2Antecedent->joinWithAND(alcoholLow, acidityModerate);

FuzzyRuleConsequent *rule2Consequent = new FuzzyRuleConsequent();
rule2Consequent->addOutput(almostRipeQuality);

FuzzyRule *fuzzyRule2 = new FuzzyRule(2, rule2Antecedent, rule2Consequent);
fuzzy->addFuzzyRule(fuzzyRule2);

// Building FuzzyRule
FuzzyRuleAntecedent *rule3Antecedent = new FuzzyRuleAntecedent();
rule3Antecedent->joinWithAND(alcoholLow, acidityHigh);

FuzzyRuleConsequent *rule3Consequent = new FuzzyRuleConsequent();
rule3Consequent->addOutput(almostRipeQuality);

FuzzyRule *fuzzyRule3 = new FuzzyRule(3, rule3Antecedent, rule3Consequent);
fuzzy->addFuzzyRule(fuzzyRule3);

// Building FuzzyRule
FuzzyRuleAntecedent *rule4Antecedent = new FuzzyRuleAntecedent();
rule4Antecedent->joinWithAND(alcoholMedium, acidityLow);

FuzzyRuleConsequent *rule4Consequent = new FuzzyRuleConsequent();
rule4Consequent->addOutput(almostRipeQuality);

FuzzyRule *fuzzyRule4 = new FuzzyRule(4, rule4Antecedent, rule4Consequent);
fuzzy->addFuzzyRule(fuzzyRule4);

  // Building FuzzyRule
FuzzyRuleAntecedent *rule5Antecedent = new FuzzyRuleAntecedent();
rule5Antecedent->joinWithAND(alcoholMedium, acidityModerate);

FuzzyRuleConsequent *rule5Consequent = new FuzzyRuleConsequent();
rule5Consequent->addOutput(ripeQuality);

FuzzyRule *fuzzyRule5 = new FuzzyRule(5, rule5Antecedent, rule5Consequent);
fuzzy->addFuzzyRule(fuzzyRule5);

// Building FuzzyRule
FuzzyRuleAntecedent *rule6Antecedent = new FuzzyRuleAntecedent();
rule6Antecedent->joinWithAND(alcoholMedium, acidityHigh);

F   RuleConsequent *rule6Consequent = new FuzzyRuleConsequent();
    nsequent->addOutput(ripeQuality);

    le *fuzzyRule6 = new FuzzyRule(6, rule6Antecedent, rule6Consequent);
    ddFuzzyRule(fuzzyRule6);
```

```
  // Building FuzzyRule
  FuzzyRuleAntecedent *rule7Antecedent = new FuzzyRuleAntecedent();
  rule7Antecedent->joinWithAND(alcoholHigh, acidityLow);

  FuzzyRuleConsequent *rule7Consequent = new FuzzyRuleConsequent();
  rule7Consequent->addOutput(overRipeQuality);

  FuzzyRule *fuzzyRule7 = new FuzzyRule(7, rule7Antecedent, rule7Consequent);
  fuzzy->addFuzzyRule(fuzzyRule7);

  // Building FuzzyRule
  FuzzyRuleAntecedent *rule8Antecedent = new FuzzyRuleAntecedent();
  rule8Antecedent->joinWithAND(alcoholHigh, acidityModerate);

  FuzzyRuleConsequent *rule8Consequent = new FuzzyRuleConsequent();
  rule8Consequent->addOutput(overRipeQuality);

  FuzzyRule *fuzzyRule8 = new FuzzyRule(8, rule8Antecedent, rule8Consequent);
  fuzzy->addFuzzyRule(fuzzyRule8);

  // Building FuzzyRule
  FuzzyRuleAntecedent *rule9Antecedent = new FuzzyRuleAntecedent();
  rule9Antecedent->joinWithAND(alcoholHigh, acidityHigh);

  FuzzyRuleConsequent *rule9Consequent = new FuzzyRuleConsequent();
  rule9Consequent->addOutput(ripeQuality);

  FuzzyRule *fuzzyRule9 = new FuzzyRule(9, rule9Antecedent, rule9Consequent);
  fuzzy->addFuzzyRule(fuzzyRule9);
}

void loop() {
  unsigned long currentMillis = millis();
  if (currentMillis - previousMillis >= interval) {
    previousMillis = currentMillis;

    float temperature = dht.readTemperature();
    alcoholSensor.readAndPrintData();
    float tegangan = analogRead(PH_PIN) * (5000.0 / 1024.0);
    float temperatur = dht.readTemperature();
    float pHValue = ph.readPH(tegangan, temperatur);

    // A   kipas berdasarkan suhu
        perature < 36) {
    oller.setFan(true); // Nyalakan kipas saat suhu < 35
    f (temperature == 36) {
    oller.setFan(false); // Matikan kipas saat suhu = 35
```

```
  }

  // Atur heater berdasarkan suhu
  if (temperature <= 36) {
    controller.setHeater(true); // Nyalakan heater saat suhu < 34
  } else if (temperature > 35.20) {
    controller.setHeater(false); // Matikan heater saat suhu > 35
  }

  controller.update(); // Perbarui kontrol heater dan kipas


fuzzy->setInput(1, getAlcoholConcentration());
fuzzy->setInput(2, pHValue);

fuzzy->fuzzify();
  Serial.print("Alcohol Level: Low-> ");
  Serial.print(alcoholLow->getPertinence());
  Serial.print(", Medium-> ");
  Serial.print(alcoholMedium->getPertinence());
  Serial.print(", High-> ");
  Serial.println(alcoholHigh->getPertinence());

  Serial.print("Acidity Level: Low-> ");
  Serial.print(acidityLow->getPertinence());
  Serial.print(", Moderate-> ");
  Serial.print(acidityModerate->getPertinence());
  Serial.print(", High-> ");
  Serial.print(acidityHigh->getPertinence());

  float tapeQualityOutput = fuzzy->defuzzify(1);

  Serial.println("Output: ");
  Serial.print("Tape Quality: Immature-> ");
  Serial.print(immatureQuality->getPertinence());
  Serial.print(", Almost Ripe-> ");
  Serial.print(almostRipeQuality->getPertinence());
  Serial.print(", Ripe-> ");
  Serial.print(ripeQuality->getPertinence());
  Serial.print(", Over Ripe-> ");
  Serial.println(overRipeQuality->getPertinence());

  Serial.print("Result: ");
  Serial.println(tapeQualityOutput);

     tapeQuality;
    QualityOutput >= 0 && tapeQualityOutput <= 3) {
    uality = "Belum Matang";
```

```
  } else if (tapeQualityOutput >= 3 && tapeQualityOutput <= 5) {
    tapeQuality = "Hampir Matang";
  } else if (tapeQualityOutput >= 5 && tapeQualityOutput <= 7) {
    tapeQuality = "Sudah Matang";
  } else {
    tapeQuality = "Terlalu Matang";
  }

  Serial.print("Kualitas Tape: ");
  Serial.println(tapeQuality);

  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print("C");

  lcd.setCursor(0, 1);
  lcd.print("Alcohol: ");
  lcd.print(getAlcoholConcentration(), 3);
  lcd.print("%");

  lcd.setCursor(0, 2);
  lcd.print("pH: ");
  lcd.print(pHValue, 2);

  lcd.setCursor(0, 3);
  lcd.print("Tape: ");
  lcd.print(tapeQuality);

  if (tapeQualityOutput >= 5 && tapeQualityOutput <= 8) {
    // Bunyikan buzzer dengan frekuensi 1000 Hz selama 1000 ms
    tone(buzzerPin, 1000, 1000);
  } else {
    // Matikan buzzer
    noTone(buzzerPin);}

ph.calibration(tegangan, temperatur);
}}
```

Lampiran 9 Biaya pembuatan sistem dan alat, serta tape singkong

No.	Nama Barang	Jumlah	Satuan	Harga	Total
A.	**Komponen Sistem kontrol**				
1.	Wadah fermentasi	1	Pcs	Rp28.000,-	Rp28.000,-
2.	Box polos pvc x6	1	Pcs	Rp16.000,-	Rp16.000,-
3.	Buzzer putih	1	Pcs	Rp7.500,-	Rp7.500,-
4.	Fan DC 12V	1	Pcs	Rp15.000,-	Rp15.000,-
5.	*Heater* udara	1	Pcs	Rp62.000,-	Rp61.250,-
6.	Relay 2 channel	1	Pcs	Rp25.000,-	Rp25.000,-
7.	LCD 2004 Biru	1	Pcs	Rp78.000,-	Rp78.000,-
8.	Sensor DHT11	1	Pcs	Rp25.000,-	Rp25.000,-
9.	Kabel Jumper	6	Pcs	Rp8.5000,-	Rp51.000,-
10.	Sensor MQ3	1	Pcs	Rp50.275,-	Rp50.275,-
11.	Sensor pH	1	Pcs	Rp314.000,-	Rp314.000,-
12.	*Power supply* 12V	1	Pcs	Rp54.000,-	Rp54.000,-
13.	Arduino Uno	1	Pcs	Rp100.100,-	Rp100.100,-
14.	Kabel serabut NYMHY	2	Meter	Rp11.500,-	Rp23.000,-
15.	Breadboard	1	Pcs	Rp20.000,-	Rp20.000,-
16.	Steker arde	1	Pcs	Rp10.000,-	Rp10.000,-
	Total harga komponen				*Rp878.125,-*
B.	**Komponen Tape Singkong**				
1.	Singkong	4	kg	Rp10.000,-	Rp40.000,-
2.	Ragi tape	10	Pcs	Rp2.000,-	Rp20.000,-
3.	Gelas ukur 500ml	1	Pcs	Rp30.025,-	Rp30.025,-
4.	Gelas ukur 10 ml	1	Pcs	Rp22.000,-	Rp22.000,-
5.	Gelas takar 1000ml	1	Pcs	Rp14.000,-	Rp14.000,-
6.	Botol 350ml	2	Pcs	Rp6.375,-	Rp12.750,-
7.	Termometer	1	pcs	Rp38.440	Rp38.440
8.	Timbangan digital	1	Pcs	Rp33.500,-	Rp33.500,-
9.	Alkoholmeter	1	Pcs	Rp79.000,-	Rp79.000,-
10.	pH meter	1	Pcs	Rp100.000,-	Rp100.000,-
	Total harga komponen				*Rp389.715,-*
	Total Biaya Keseluruhan				**Rp1.267.840,-**