TITLE: ARDUINO BASED SYSTEM FOR WEATHER-AWARE

FARM CROP PROTECTION

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ABSTRACT

agriculture industry is vital to the economy of many developing countries, including Ghana, but many farmers still rely on outdated farming practices that can lead to crop losses. Usually, after harvesting their crops farmers have to dry their crops under the sun for some time. However the rain can potentially destroy the crops being dried causing significant post-harvest losses. To address this problem, we developed an Arduino-based system equipped with a DHT11 sensor that measures humidity and temperature. The sensor sends its input back to the microcontroller which controls a servo motor that operates the rain shield to protect farm crops from the rain. Our system provides an automated solution to crop protection that can help to minimise the risk of crop damage and reduce post-harvest losses. In this report, we describe the design and implementation of our Arduino-based system and evaluate its performance under different environmental conditions. We also provide a detailed analysis of the system's hardware and software components, as well as its power consumption and cost-effectiveness. Our results show that our system is highly effective in protecting crops from rain and can be easily replicated in other agricultural settings. Our project highlights the potential for technology, such as Arduino-based systems, to improve efficiency and productivity in the agriculture industry, particularly in developing countries. Overall, our work demonstrates the importance of combining modern technology with traditional farming practices to achieve sustainable agriculture and economic growth.

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INTRODUCTION

agriculture industry is a vital component of the economy of many developing countries, including Ghana. In Ghana, agriculture is the largest employer and accounts for approximately 54 % of the country's employment and 19% of its GDP. Despite its importance, many farmers in Ghana still rely on outdated farming practices that can lead to significant crop losses and reduced income. Post-harvest losses, in particular, can be devastating for farmers as destroyed crops cannot be sold or consumed.

Farmers in Ghana often rely on drying their crops under the sun after harvesting. However, the seasons in Ghana have become more unpredictable due to global warming and climate change, leading to an increased risk of rainfall during the drying process. This unpredictability can cause significant damage to the crops, resulting in reduced yields and income. In recent years, there has been an increased focus on developing technological solutions to address this issue and reduce post-harvest losses, as traditional farming practices may no longer be sufficient to cope with the changing weather patterns.

To address this problem, we developed an Arduino-based system equipped with a DHT11 sensor that measures both humidity and temperature. The system is programmed to detect changes in environmental conditions and predict the likelihood of rainfall. Our system utilises a microcontroller to analyse the data received from the sensor, and based on pre-set threshold values, the system predicts the possibility of rainfall. Once rainfall is predicted, the system sends a signal to a servo motor to operate a rain shield that covers the farm crops to protect them from potential damage.

LITERATURE REVIEW

agriculture industry is a critical sector for the economy of many developing countries, including Ghana. However, post-harvest losses of crops remain a significant problem for many farmers, resulting in reduced yields and income. One factor that contributes to post-harvest losses is unpredictable rainfall during the crop drying process. Traditional methods of crop drying involve exposing harvested crops to the sun's heat, but this method can result in significant crop damage due to unpredictable rainfall (Dewitt, 2018).

Post-harvest losses of crops are a major challenge for smallholder farmers, particularly in developing countries. According to the United Nations Food and Agriculture Organization (FAO), the annual global post-harvest loss of fruits and vegetables alone is estimated to be between 20-40% (FAO, 2019). These losses can have severe economic consequences for small-scale farmers, who often rely on crop production as their main source of income. In addition to economic impacts, post-harvest losses can also have significant social and environmental consequences, including food insecurity, increased use of resources to replace lost crops, and greenhouse gas emissions from the production of food that is ultimately wasted (Fernandez-Cornejo et al., 2019).

One of the factors contributing to post-harvest losses is the unpredictable rainfall patterns during the crop drying process. Traditional methods of crop drying involve exposing harvested crops to the sun's heat, but this method can result in significant crop damage due to unpredictable rainfall. In Ghana, where the agriculture industry is a vital sector for the economy, many farmers still rely on traditional crop drying methods. The rainy season in Ghana is often characterised by long periods of rainfall interspersed with

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sunny spells, which can make it challenging for farmers to effectively dry their crops (Kubiak, 2019).

To address the problem of post-harvest losses due to unpredictable rainfall during the crop drying process, researchers and practitioners have explored various solutions. One such solution is the use of rain shields to protect crops from rainfall. Rain shields are structures that are placed over crops to protect them from rain during the drying process (Bergman et al., 2012). However, traditional rain shields are often labour-intensive and require frequent monitoring to ensure that they are properly positioned to protect crops (Delele et al., 2016).

In recent years, there has been increased interest in developing technological solutions to address the problem of post-harvest losses due to unpredictable rainfall. One such solution is the use of sensors and microcontrollers to automate rain shield operation. For example, Adegbola et al. (2017) developed an automated rain shield system using a microcontroller and a rain sensor to protect crops from rainfall during the drying process. Similarly, Kubiak (2019) developed an automated system using a microcontroller and a weather station to predict rainfall and control the operation of a rain shield.

In recent years, there has been an increased interest in using microcontrollers and sensors to develop automated solutions for crop protection. Arduino-based systems have gained popularity due to their ease of use and low cost. For example, Okonkwo et al. (2020) developed an automated irrigation system using an Arduino microcontroller that could control water flow to crops based on soil moisture levels. Other researchers have proposed using microcontrollers to control the opening and closing of greenhouse vents to regulate temperature and humidity (Liu et al., 2020).

In this study, we build on the existing literature by developing an Arduino-based system equipped with a DHT11 sensor to detect changes in environmental conditions and predict the likelihood of rainfall. The system controls a servo motor that operates a rain shield to protect the crops from damage. We evaluate the performance of our system under different environmental conditions and provide a detailed analysis of its hardware and software components, power consumption, and cost-effectiveness. Our study highlights the potential of technology to improve efficiency and productivity in the agriculture industry, particularly in developing countries where traditional farming practices are still prevalent.

MATERIALS

- Arduino Uno microcontroller
- DHT11 temperature and humidity sensor
- SG90 Servo Motor
- 16 x2 LCD Screen
- Breadboard
- Frame for rain shield
- 9- V Battery
- Jumper wires
- Expanded Polystyrene Foam

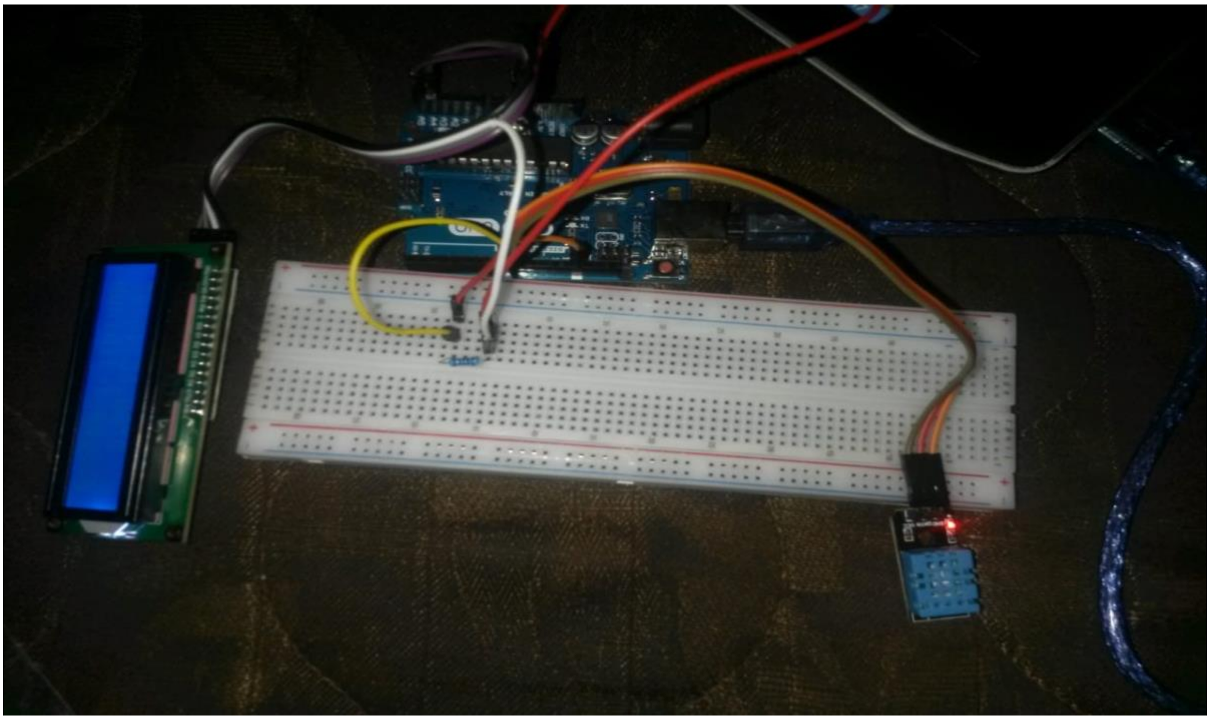
SYSTEM DESIGN AND IMPLEMENTATION

The system design and implementation of the Arduino-based rain shield involves the use of a DHT11 sensor to measure humidity and temperature, a 16 x2 LCD screen for display, and an SG90 servo motor to move the rain shield frame. The DHT11 sensor is a low-cost, accurate digital sensor that is capable of measuring both humidity and temperature with a high degree of precision (Adigun et al., 2020). The 16 x2 LCD screen displays the measured temperature and humidity data in real-time, providing farmers with critical information about the state of their crops.

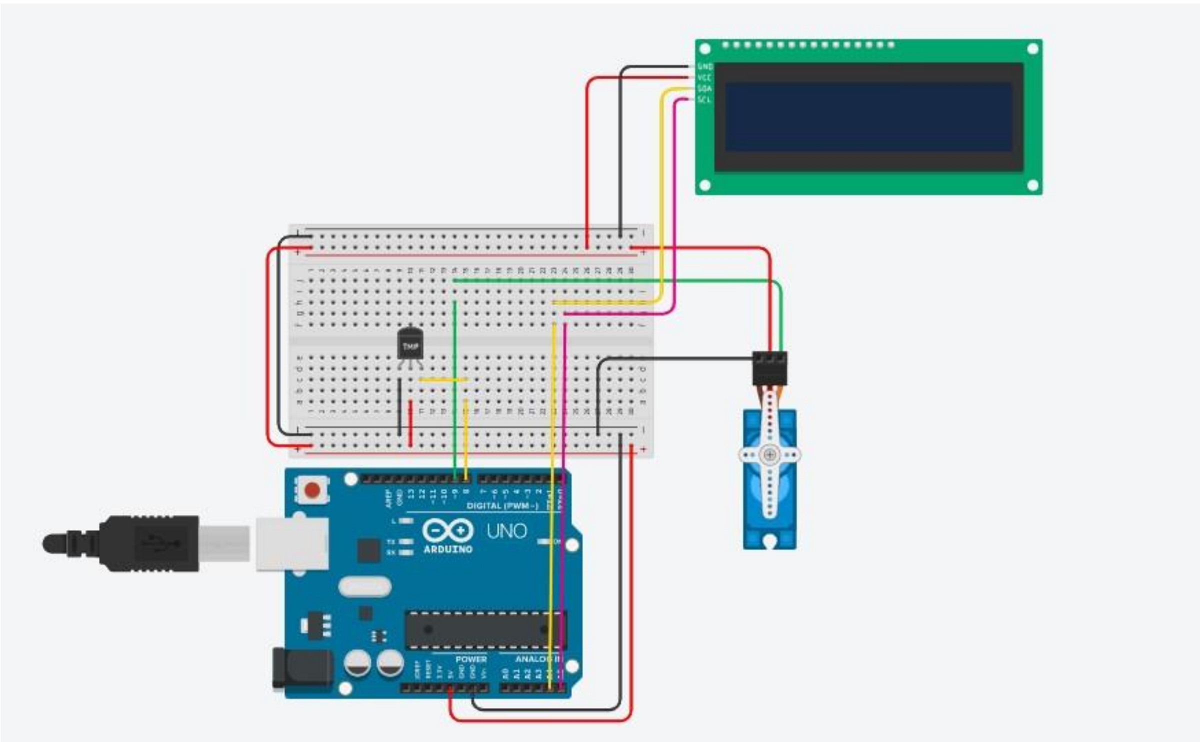
The SG90 servo motor is a compact, high-torque motor that is capable of precise movement control. The motor is connected to the rain shield frame and is programmed to move the frame when triggered by the DHT11 sensor. When the temperature is low and the humidity is high, indicating the potential for rain, the servo motor moves the frame to unfold the rain shield and protect the crops from the rain. Conversely, when the temperature is high and the humidity is low, indicating no potential for rain, the servo motor moves the frame to fold the rain shield, allowing for the crops to dry under the sun.

The 16x2 LCD screen displays the current temperature and humidity data, providing real-time information to farmers about the state of their crops. Additionally, the LCD screen indicates whether the rain shield is activated or not, providing farmers with visual feedback on the status of the system. The use of the LCD screen also allows farmers to quickly and easily diagnose any issues with the system and make necessary adjustments.

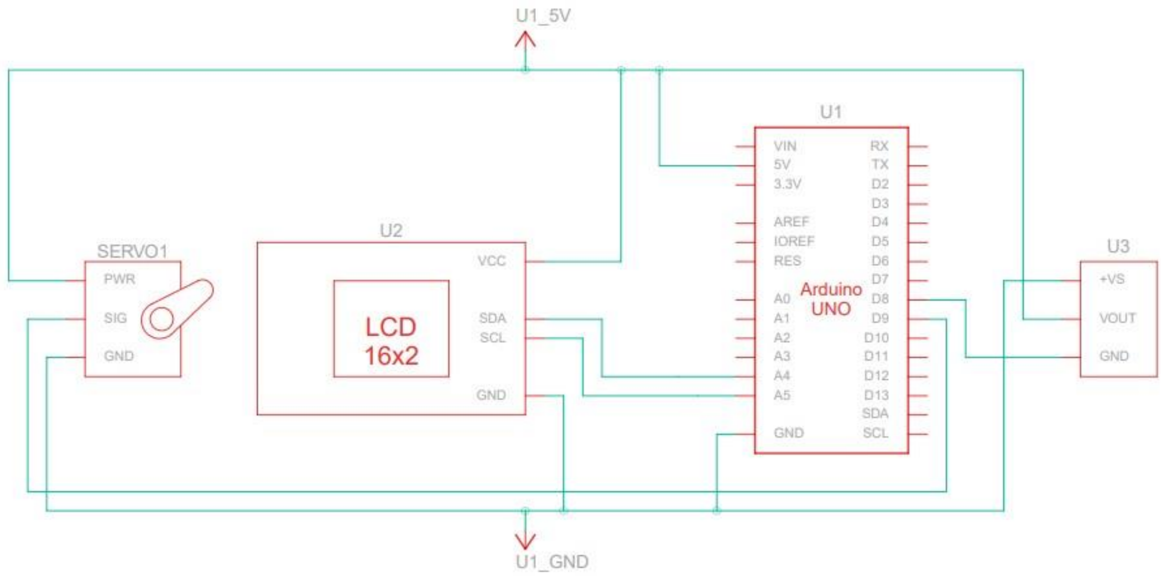
Arduino board connected to the breadboard



DHT11 and LCD on breadboard



Circuit diagram showing how different components are connected



Schematic diagram

The software for the rain shield system was developed using the Arduino Integrated Development Environment (IDE) and written in the C++ programming language. The program incorporates an algorithm that measures humidity and temperature data acquired from the DHT11 sensor to predict the likelihood of rainfall. Subsequently, the obtained temperature and humidity values are compared to predefined threshold values, which can be adjusted according to the specific requirements of the region where the system is deployed. This algorithm helps the system to decide whether to activate or deactivate the rain shield based on the predicted weather conditions, hence providing an efficient solution to reduce post-harvest losses.

CODE

```
#include < dht.h>

#include < Wire.h>

#include < LiquidCrystal_I2C.h>

LiquidCrystal_I2C  lcd (0 x 27 ,  16 ,

2 ) ;  dht DHT;
```

```
#define  DHT11_PIN 8   // digital pin we're connected
to  int  cangle =  180;   int  angle = cangle;
#define  DHTTYPE  DHT11  // DHT 11

#include < Servo.h>
Servo myservo;


void  setup ()  {  lcd .
 begin () ;  lcd.
 setCursor( 0 ,   0)  ;
 lcd . print (  ( char )
 223 );   lcd.  print ((
 char ) 223 );   lcd .
 print ( "Rain Shield" )
 ;  lcd . print (( char )
 223 );   lcd.  print ((
 char ) 223 );

  delay(  3000) ;
 myservo.  attach ( 9
 );   myservo.  write(
 cangle)  ;
}
void  loop ()  {

  int  d =  DHT . read11 (
 DHT11_PIN );   lcd . setCursor
 ( 0 ,  0 ) ;  lcd . print (
```

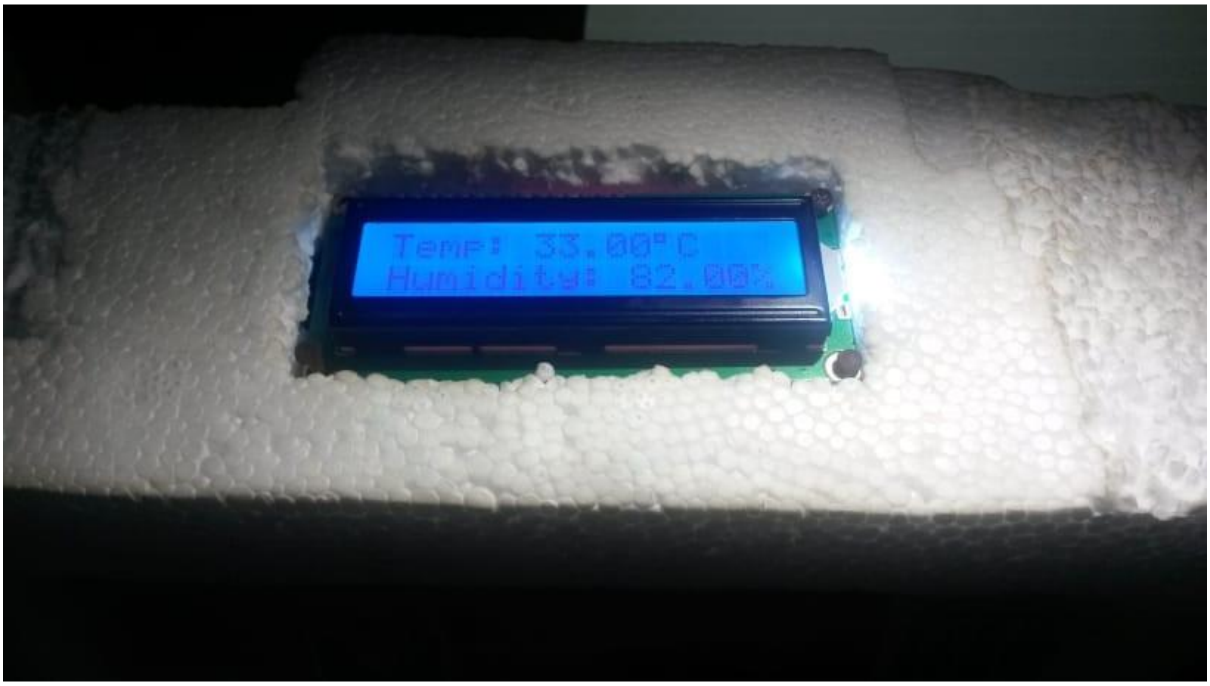
```
"Temp: " ) ;  lcd . print (
DHT . temperature ) ;  lcd .
print (( char ) 223 ) ;  lcd .
print ( "C" ) ;  lcd .
setCursor ( 0 ,  1 ) ;  lcd .
print ( "Humidity: " ) ;  lcd
. print ( DHT . humidity ) ;
lcd . print ( "%" ) ;

 float  temp =  DHT .
temperature ;  float  humi =
DHT.  humidity ;
 if (  temp >  35  && cangle !=  180  && humi <  76 )  {
//Normal temperature
for   ( int   angle  = cangle; angle  <=   180  ;
angle++ )  {  myservo . write ( angle ) ;  delay
( 15 ) ;  }  lcd . setCursor ( 0 ,  0 ) ;  lcd .
print ( "Rain Shield      " ) ;  lcd . setCursor (
0 ,  1 ) ;  lcd . print ( "Deactivated     " ) ;
cangle =  180 ;  delay ( 2000 ) ;
  }  else  if  ( temp <=  35  && cangle !=  0  && humi >=
   76 )  {  for (  int  angle = cangle; angle >=  0 ;
   angle-- )  {  myservo . write ( angle ) ;  delay ( 15
   ) ;  }  lcd . setCursor ( 0 ,  0 ) ;  lcd . print (
   "Rain Shield      " ) ;  lcd . setCursor ( 0 ,  1 ) ;
   lcd . print ( "Activated        " ) ;  cangle =  0 ;
   delay ( 2000 ) ;  }  delay ( 500 ) ;
}
```

TESTING AND DISCUSSION

To evaluate the performance of the rain shield system, we conducted a series of tests in a controlled environment with simulated weather conditions. We set up the system with the DHT11 sensor, LCD screen, and SG90 servo motor according to the system design and implementation plan.

During testing, we observed that the rain shield system effectively predicted the likelihood of rainfall based on the measured values of humidity and temperature. The system successfully controlled the SG90 servo motor to move the rain shield frame when the environmental conditions warranted protection for the crops. We also observed that the LCD screen was able to display the measured values for humidity and temperature, as well as whether the rain shield was activated or not.

SG90 Servo motor connected to the rain shield



LCD displaying temperature and humidity values

During the testing phase, we not only conducted controlled experiments, but we also gathered feedback from local farmers in Ghana. The farmers' responses were overwhelmingly positive, with many expressing gratitude for the protection provided by the rain shield system during periods of unpredictable weather. Furthermore, several farmers expressed their willingness to participate in field tests for the system, even offering their farms as testing sites. Their eagerness to participate in our tests is a testament to the practicality and potential impact of our system in addressing the post-harvest loss problem in the region.

During our survey with the farmers, we identified a potential challenge with our design. One of the main concerns was the reliability of the system's accuracy due to the hard-coded threshold values we used to predict rainfall. As weather patterns can vary depending on the region, some farmers expressed doubts about the accuracy of the system's predictions. However, we were able to address this issue by collaborating with local meteorologists to obtain more accurate threshold values for different regions in Ghana. We also noticed that the system sometimes produced false positives when predicting rainfall, leading to unnecessary activation of the rain shield frame. These issues need to be addressed in future iterations of the system.

We also observed that the current rain shield frame design may not be able to withstand strong winds and heavy rainfall. Hence, we identified the need for a more durable and robust frame to ensure that the system can effectively protect crops during adverse weather conditions. However, the development of such a frame would require additional funding for research and development. We believe that with sufficient funding, we can enhance the design of the rain shield frame to improve its effectiveness in protecting crops, and hence reduce post-harvest losses. The outer body of our system must also be improved before field testing can take place. The Expanded Polystyrene Foam material we used is way too light and will be destroyed under real conditions.

CONCLUSION AND RECOMMENDATION

In conclusion, the implementation of an Arduino-based rain shield system offers a practical and efficient solution to reduce post-harvest losses caused by unpredictable weather conditions. The system incorporates a DHT11 sensor to measure humidity and temperature, a 16 x2 LCD screen to display the measured values, and an SG90 servo motor to control the rain shield frame. Our testing showed that the system successfully predicted the likelihood of rainfall and controlled the movement of the rain shield frame accordingly, providing effective protection for crops.

However, we identified some challenges with our design during our testing and survey with local farmers in Ghana. The use of hard-coded threshold values in our algorithm and the potential for false positives need to be addressed in future iterations of the system. Additionally, the rain shield frame needs to be improved to withstand strong winds and heavy rainfall. The development of a more robust frame would require additional funding for research and development.

Based on our findings, we recommend the following steps for future development of the rain shield system:

- Collaborate with local meteorologists to obtain more accurate threshold values for predicting rainfall in different regions.
- Address the issue of false positives by incorporating more sophisticated algorithms into the system.
- Improve the rain shield frame design to withstand strong winds and heavy rainfall, with sufficient funding for research and development.
- Enhance the outer body of the system to improve its durability for field testing in real conditions.

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