Simulation of Arduino UNO(R3) based Smart Systems for Effective Online Teaching

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ABSTRACT

This paper presents an Arduino Uno based study and simulation of smart digital systems on Tinker-CAD for an effective online teaching purpose. Digitally designed various circuits for gas sensors, infrared sensor, light intensity sensor, distance sensor and smart irrigation system are simulated to explain the functioning of various smart systems. The results are quite interesting and effectively explain the systems in the absence of any hardware. This serves as a boon to various people who are going to design any smart sensing system prior to going with a real time hardware. This also serves a great purpose for students studying online.

Keyword: - *Arduino Uno, Smart System, Temperature sensor*

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1. INTRODUCTION

COVID-19 pandemic, recently occurring across the world has quickened the pace of online education's development [1, 2]. Its virtual circuit simulation and smart systems design experiences surpassing traditional hands-on learning approach are making Tinker CAD and Arduino Uno integration a new way of learning [3-8]. By eliminating the physical component, this method remains effective to enhance accessibility and cost-effectiveness even in remote areas. Simulations in Tinker CAD allow students keep on testing and correcting their designs without wasting much time, efforts, and physical resources in conducting experimental investigations.
Arduino Uno is a microcontroller board based on the ATmega328P having 14 digital input/output pins and 6 analog input pins. The microcontroller operates at 16 MHz master clock generated on board using ceramic resonator. A variety of peripherals are available required for operation and support of the microcontroller. It is also equipped with a USB port and can be interfaced directly with a computer connection. A picture of the board with pinout details is displayed in Fig. 1(a) and its common use as a sensing circuit using the board is shown in Fig. 1(b). It may be seen that multiple sensors and actuators may be connected to this board, which can function concurrently. The Arduino Uno(R3) board has been shown to be an effective as well as economical solution in our earlier work for Fourier analysis of periodic signals [6], real time sensing of visible wavelengths [7] and heath monitoring system [8]. In the present work, the sensing and control circuits based on Arduino Uno board have been simulated in Tinker CAD to receive and process the signals from the temperature sensor, humidity sensor, LDR sensor etc. and to provide output in a desired manner, such as display on a LED screen, which may be combined to work concurrently to realize a smart system.

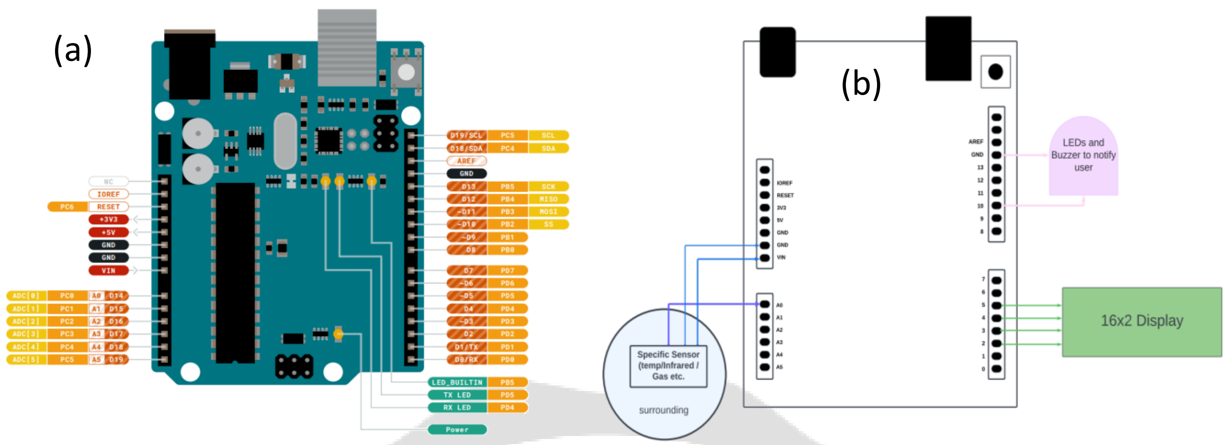

Fig -1: (a) Arduino Uno (R3) pinout diagram, (b) Schematic circuit of Arduino uno with sensor interface

2. THE PROPOSED SMART SYSTEM

A system that can sense its environment, assess the situation, and take decision to react accordingly can be termed as a smart system. Such systems are required in a variety of industrial, medical, agriculture and other domestic applications, such as fire-fighting and automating the disasters management. The most common systems require the sensing of temperature, humidity, pressure, distance, smoke and light level and the outcome is usually required in form of buzzer/alarm, alpha-numeric display, ON/OFF switch control, motor speed control etc. In this work, we explain the simultaneous use of sensors and actuators to realize a smart system, i.e., irrigation system, wherein the sensing mechanism and the system response are controlled by the Arduino Uno.

To explain the functions in detail for readers benefit and for the online teaching purpose, we first illustrate the individual sensors interfaced with the Arduino Uno(R3) board one by one using Tinker CAD simulation platform. Then we use multiple sensors and controllers to realize a smart system useful for the agriculture. Though the illustration is for the persons involved in agriculture, the implementation is generic and may be used for other purpose as well.

2.1 Temperature Sensing

A temperature sensor has been interfaced with the Arduino Uno board for getting the real time temperature input and for its display, a 16×2-character LCD display has been used as illustrated in circuit diagram shown in Fig. 2. The temperature sensor has 3 legs, one connected to the Arduino UNO (R3) Analog pin A0, another one to +5V supply and third one to the ground. The connections have been made on a breadboard, which allows connections between the components without the need for soldering. The code has been written to program the Arduino to read the value from the sensor, and then send it to the LCD display as a visualization of the results. This also provides facility of data logging, which can further be customized with a display unit and the temperature records for analytic purposes.

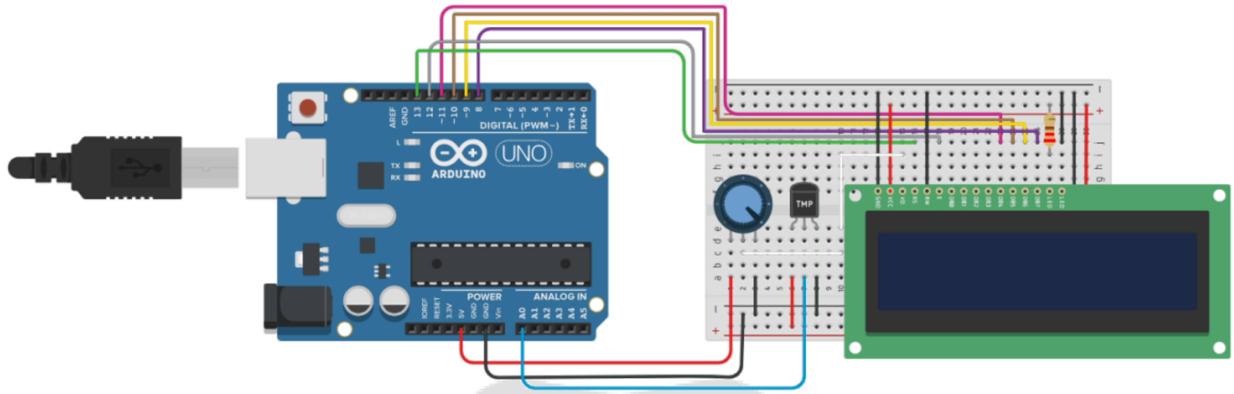

Fig -2: Temperature sensor circuit along with the display simulated in Tinker CAD

2.2 Light Level Sensing

Circuit diagram for SDR with Arduino is shown in the Fig. 3. Analog pin A0 of Arduino is connected to the light dependent resistor (LDR). Arduino process the signal received from the sensor and accordingly the different colored LEDs are turned OFF or ON. Similar connection is made to the buzzer from the digital pin 5 of Arduino to alert the user as needed. This arrangement does not require any specific pins, any analog and digital pins can be used for the same.

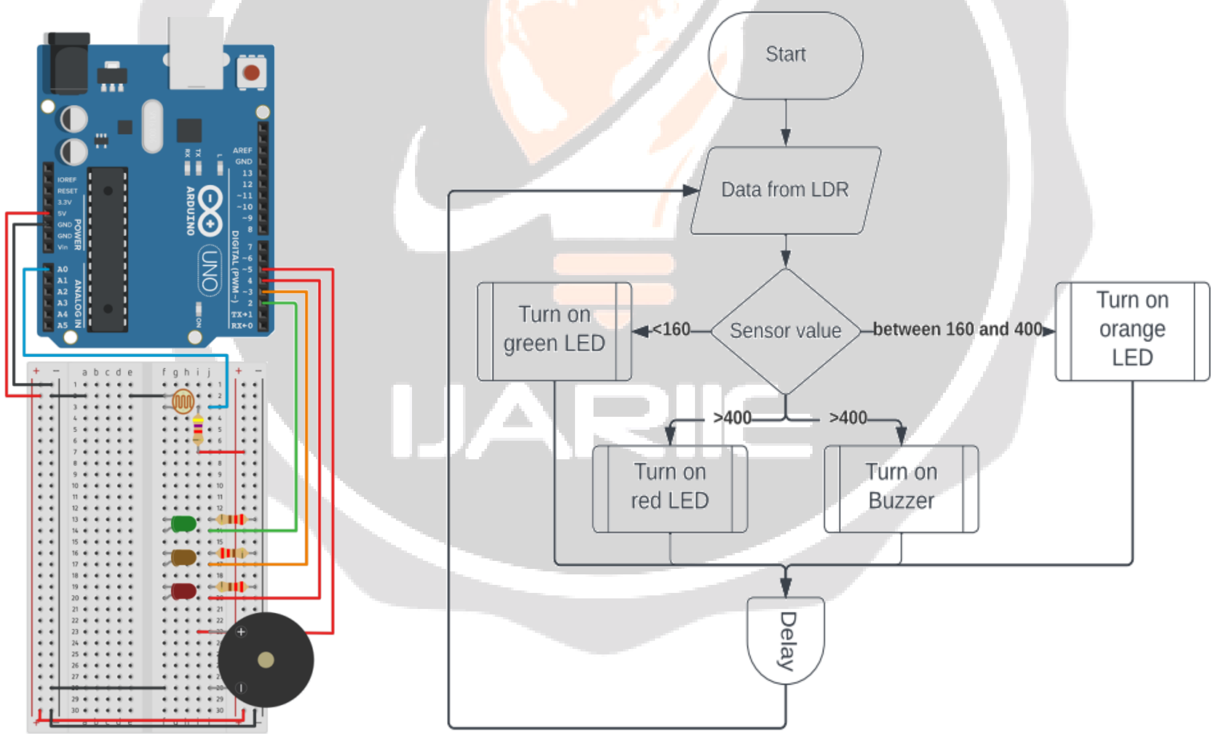

Fig -3: Light sensing using LDR interfaced with Arduino with algorithm simulated in Tinker CAD

2.3 Distance Sensing

The ultrasonic signal pulse if transmitted from a certain location towards an object and the reflected signal is received at that location, the distance between the object and the specified location can be computed by knowing the velocity of the ultrasonic signal. Using the same principle, a potentiometer and ultrasonic sensor can be used to detect objects and compute their distances. The circuit arrangement simulated in Tinker CAD for distance measurement is shown in Fig. 4, wherein a standard ultrasonic sensor has been utilized. The ultrasonic sensor module transmits the signal when its "trigger" input is excited. The event of receiving the return pulse is sensed at the "echo" pin. The trigger and echo pins have directly been connected to i/o pins 18(A4) and 19(A5) of Arduino. A 16×2 LCD is connected to Arduino in 4-bit mode. Control pin RS, RW and En are directly connected to Arduino pin 2, GND and 3. Data pins D4-D7 are connected to 4, 5, 6 and 7 of Arduino. This setup computes the distance by noting time stamps corresponding to the sending and receiving of the signal. The precision of the depends on the least count of time measurement and frequency of the sensor. However, to have better accuracy and confidence, the measurements may be calibrated with a standard procedure.

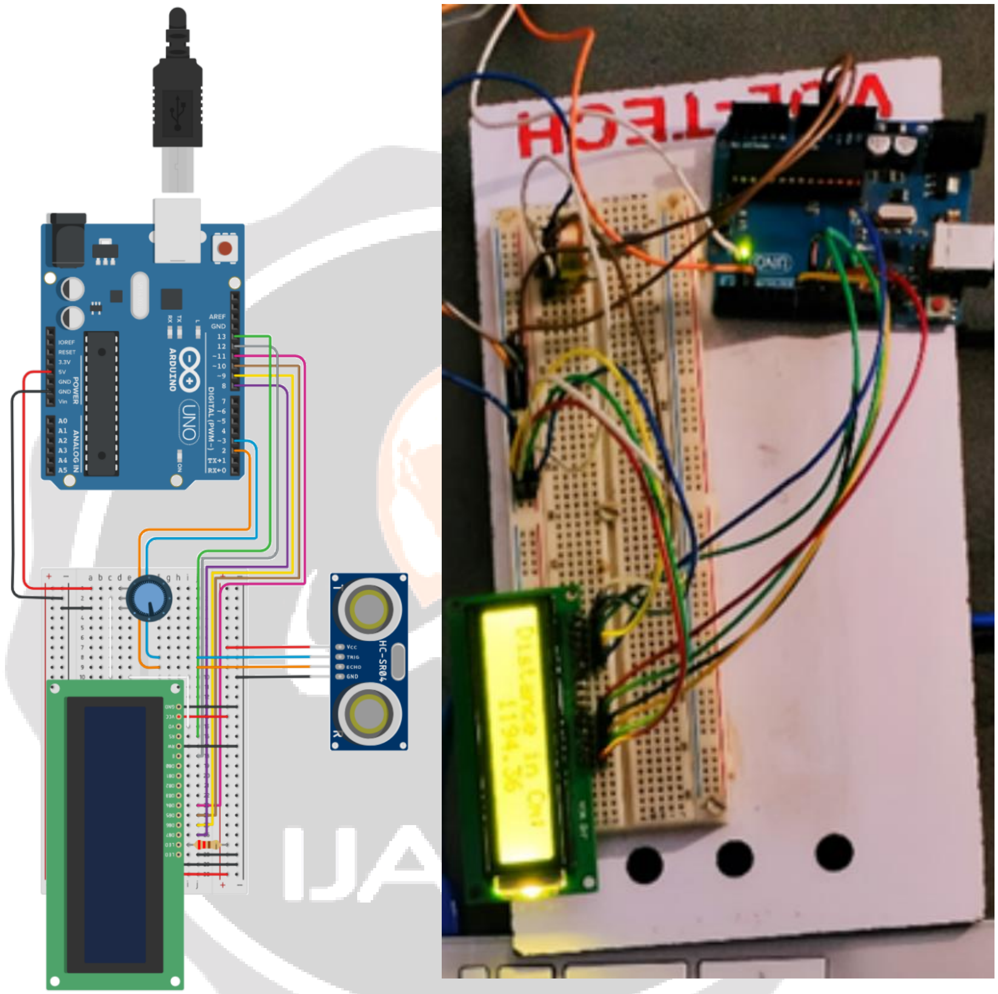

Fig -4: Distance measurement circuit simulated in Tinker CAD and practically implemented on breadboard

2.4 Passive Infrared Sensor for Intruder Alarm

The objects near room temperature emit the electromagnetic radiations that falls within the infrared band of spectrum. The Infrared sensors receive this emitted radiation and detect the objects such as human body or animals, without illuminating them, therefore referred as passive. Fig. 5 shows the circuit arrangement for passive IR sensing to monitor the intruder motion. Here, two potentiometers have been used to adjust the sensitivity of the sensor. To adjust the time the output signal stays high when object is detected ranging from 0.3 seconds to 5 minutes. The module has three pins, a ground and a VCC for powering the module and output pin which gives digital signal connected to the analog A0 of the Arduino.

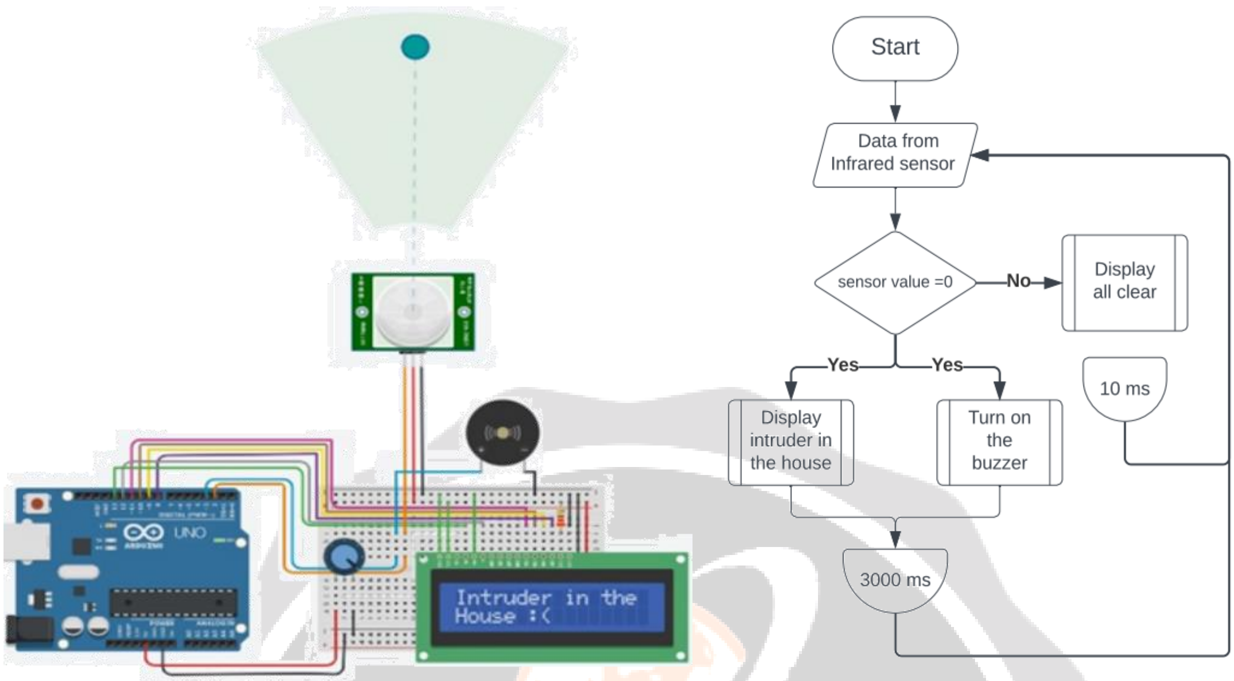

Fig -5: Circuit arrangement for IR detection and associated algorithm to detect the intruder motion

2.5 Motor Control for Pumping Water

To regulate the water pumping in the field, Arduino board may be utilized to switch ON or OFF the motor or control its speed. The decision of motor control is taken based on the atmospheric temperature. A typical circuit for this purpose is shown in Fig. 6, wherein, analog pin A0 is used to get temperature from the temperature sensor and digital pins 2 to 7 are connected to the LED display to show the temperature. Digital pins 11,12 and 13 are used to control the motor as per user's predefined conditions in the code. The motor status is also displayed on the LED screen.

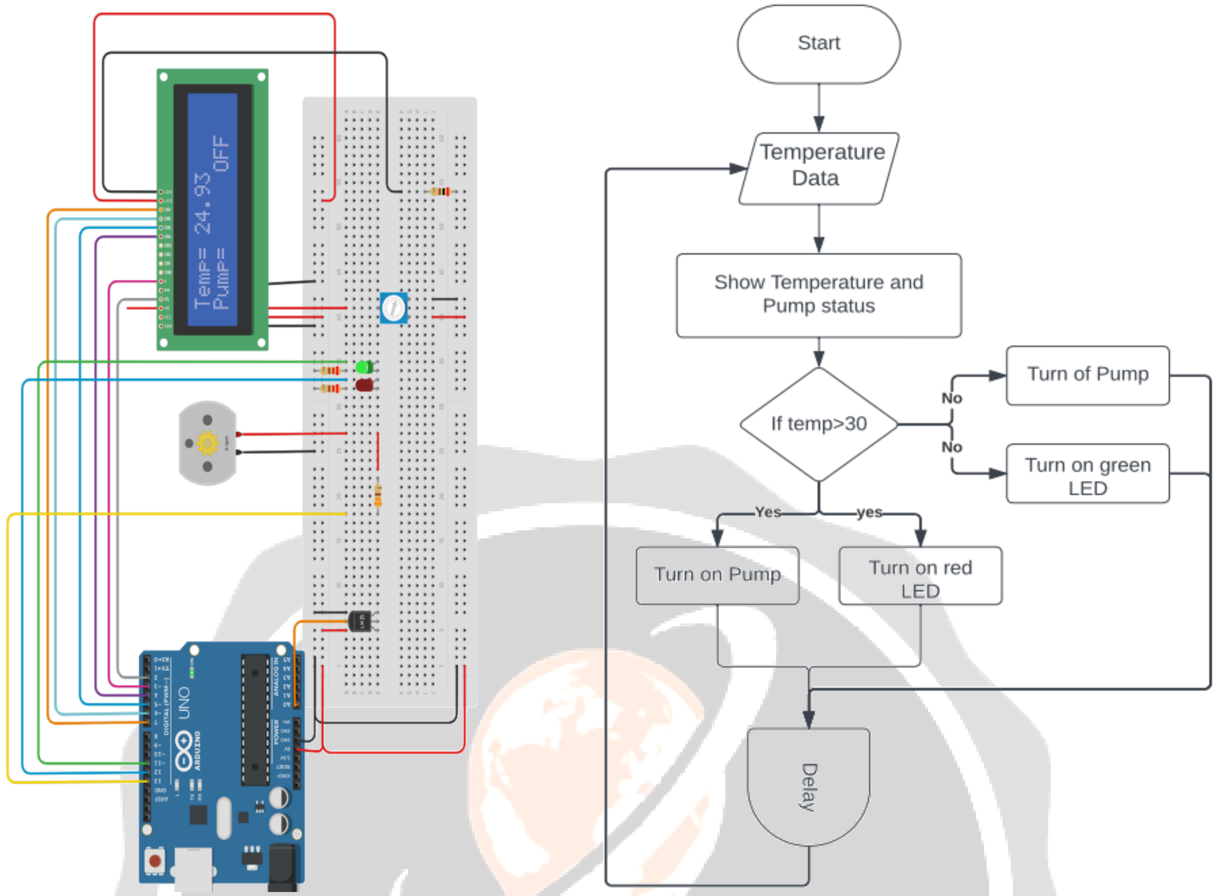

Fig -6: A circuit for controlling the water pump with algorithm simulated in Tinker CAD

2. A SMART SYSTEM FOR AUTOMATION IN AGRICULTURE

Here we have integrated Arduino Uno, temperature sensor LM35, Photoresistor, Passive Infrared sensor (PIR) to make smart irrigation system which controls irrigation pump depending on the temperature and light condition of the field. At the same time PIR detects any motion in the field (expected to be of animals) and turn on the buzzer alerting the farmer. The temperature sensor triggers the pump if temperature is more than 40 ºC saving the crops. Similarly. the photo resistor detects light in the field and shows it in three colored LEDs: red, orange and green. If sensor value from LDR is higher than 400, it turns ON the pump making the crops safe from harsh sunlight. If sensor value is between 160 and 400, orange LEDs is turned on showing perfect condition for photosynthesis. The green LEDs is used when sensor value is lower than 160. Thus, crop is saved from both high temperature and harsh sunlight. PIR sensor turns on the buzzer and red LED alerting the farmer when detects any motions. Thus, this system can helpful for farmer to automate irrigation and save from stray animals. These sensor values and pump status can be monitored for a day or a week or a month to understand temperature and lighting conditions and patterns of that areas which can be useful for other activities such solar panel adjusting to get maximum sunlight.

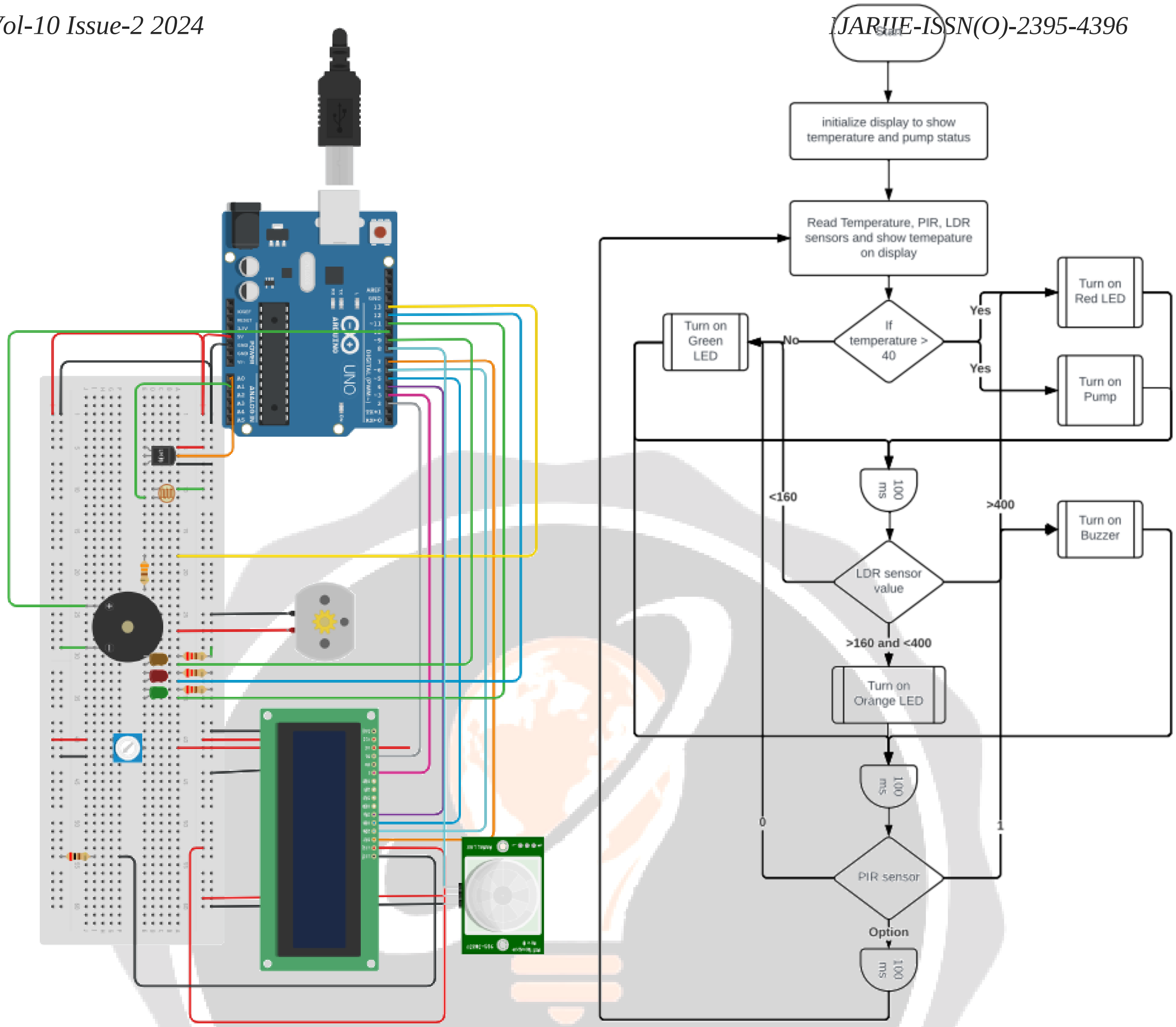

Fig -7: A combination of various sensors to realize a smart system for automation in agriculture along with the associated control algorithm

3. CONCLUSION

Using a simulation platform on Tinker CAD, we have demonstrated that Arduino Uno may be utilized for realizing a variety of systems having sensors and actuators with active control. We also demonstrated experimental realization of a few of these circuits to practically validate the simulated performance. Such systems can be very useful where we need unattended control of multiple parameters based on the situational awareness. As an illustration, we have simulated a smart system for agricultural control that not only controls the irrigation but also may assist the farmers in many ways. This also demonstrate the usefulness of such platforms for online learning and teaching.

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