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Development of solar tracker with insect trapping mechanism

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Abstract
A mechanism has been developed to control the insect in agricultural fields, gardens, and solar trackers. In this mechanism, a solar tracker is typically employs to store the solar energy into batteries, 30–40% more than a static solar system, and the stored energy will be used to glow the LED light at night, which will glow automatically at night using a self-made circuit. All these are controlled by an Arduino Uno microcontroller. For trapping the insects, a fluid tank is used in which water and kerosene (a small amount used to reduce the surface tension) are used to trap them by attracting them with LED light. The fluid tank's water will be drained out using a drain plug at the base of tank, and trapped insects are buried in the soil, which produces humus and increases the fertility of the soil. One buzzer uses to drive away the animals from the field by making sounds.

Keywords: Solar tracker, static solar system, LED, Arduino uno, fluid tank, buzzer etc

Introduction
The development of a solar tracker with an insect trapping mechanism is an idea to trap the insect as well as store more solar energy by tracking the sun. This project helps farmers by providing a low-budget insect trapping mechanism for their field with a single low-investment in initially and low-maintenance charge. It is the best use of solar energy for farmers to solve the insect problem in the field without using any health-hazardous chemicals to kill the insect [1], which also affects human health. It is a combination of the solar tracker mechanism, which is dynamic and stores more energy as compared to the static solar system [1, 2, 3]. Tracking the sun, we used a LDR for tracking the sunlight position and a servo motor 180 to rotate the solar panel based on direction of the sunlight [6]. For trapping mechanisms, simple and useful methods are used, such as a fluid tank. Generally, we use water with some kerosene (To reduce the surface tension of the water), and for attracting insects across the fluid tank, we use LED lights and make a circuit using a LDR, resistance, BC547, and 1N40007 diode to automatically turn off the LED light during the day and on at night. A buzzer is also used in this project, in which, at the end of the day, it will sound for 10 minutes to protect the cultivated field from the animals. Functioning all the above-mentioned functions is possible with the Arduino UNO microcontroller, which controls all functions like the solar tracker mechanism, buzzer, power supply to the LED, and charge control. It will be useful for farmers as well as for garden use [2]. It is easy to setup, easy to handle, and the maintenance cost is very low. It can be used as an alternative solution to chemicals in fields that are harmful to human health and reduce the fertility of the land [2, 3, 4]. We did trials on the field for a few days twice in two crops, one in a paddy field and another in a wheat field. The solar tracking mechanism stored 30–40% more energy as compared to a static solar system [4]. Insects were trapped in the fluid tank, and there were different categories of insects.

Materials and Methods
The development of the solar tracker with an insect trapping mechanism requires different electronic components as well as iron pipes and steel sheets, and the various required materials for the development of this mechanism are as follows: Solar panel, battery, LED light, servo motor 180, LDR sensors, fluid tank, rectangular and circular iron pipes, steel sheets, nuts and

bolts, Arduino UNO, motor driver, buzzer, resistance, In40007 diode, Bc547 transistor, jumper, normal wire, and mseal. 140 cm of four stand legs are required to provide support and stand on the field. The fluid tank, which is 80*80 cm and has a height of 10 cm, is made with water leak-proof material, which will hold the fluid in the tank. Another stand for the solar tracker was welded to hold the servo motor and allow the rotation of the solar panel [5]. Dimension was taken as per solar panel size which is 20*35 cm. Four stand legs are welded with 80*80cm pipes, which will hold the fluid tank, and another sheet is welded in the shape of a battery to hold the battery and protect it from rainwater, which is at beneath of fluid tank. The fluid tank is made of steel sheets with leakage protection. In the fluid tank, there is also one drain plug for the water.

The components required for fabrication and the development of this mechanism are the following

S. No.	Components	Descriptions
1	Frame/Stand	The base of the mechanism has four legs, and a rectangular rod is welded in which the fluid tank is mounted on top, and the solar tracking mechanism is also mounted vertically on the centre of the fluid tank. In this frame, one slot is made for the battery at lower part of tank, which protects the battery from rainwater by shading it.
2	Fluid tank	A 3-4mm steel sheet, to make the leak-proof fluid tank, whose dimension is 80*80cm and height is 10cm. The canter of the tank has one hole for mounting the solar tracker mechanism on top. In this tank, another hole with tight nut & bolt is attached in beneath of tank to drain out the water or fluid from tank.
3	Solar tracker's stand	A circular iron rod to support the solar panel, with one iron sheet on top and two sidewall supports with holes, and a servo motor support is welded.
4	Solar panel	A 12-volt solar panel, to charge the battery as well as rotate by following the sun's position. In the solar panel, one servo motor (180) is attached to the side of the panel, and a LDR is also attached.
5	Battery	Two 12-volt, 7.1 Ah battery, to run the servo motor 180, motor driver, buzzer and 5-volt supply to the microcontroller (Arduino Uno).
6	Servo motor 180	This is for rotate the solar panel, which is attached on solar panel's side wall, based on high-frequency light detected by LDR.
7	Arduino Uno	This is a microcontroller used to control the various rotations of the servo motor as per LDR sensor's response. It also controls the sounding time of buzzer which is 10 minutes in each one hour.
8	Motor driver	This component is used for supplying the power in equal amount to its two output terminals which is typically does sound the buzzer and 5volt power supply to Arduino uno.
9	LDR sensor	LDR sensors are connected to detect the sun light, its two uses in this project one is to detect the sun frequency high/low for solar tracking mechanism and another use is to detect sun to on/off the LED light at night [6].
10	Buzzer	It is usually employs to drive away the animals from the cultivated field to protect the crops by sounding for 10 minutes each hour.

Methodology

The different steps involved in assembling the parts for the mechanism are here:

The assembly procedure consists of multiple essential steps, which include welding rectangular rods into an 80x80 centimetres frame to support the fluid tank and solar tracker assembly. The mechanism's stand consists of made of four 140 cm length rectangular iron rods that are welded to this frame. Further, a diagonal iron rod is welded into the top of the stand to support the solar tracker assembly and secure the batteries. Three iron plates are welded at 90-degree angles to make a structure that holds the battery on the rod, and a 5 cm circular pipe is welded on top of the diagonal rod.

The fluid tank, formed from thin steel sheets 2-3 mm thick, is 80x80 cm and has a height of 10 cm. It is securely mounted to a rectangular iron support without welding or bolting, it includes a centre hole that holds the solar tracker stand parts. The solar tracker assembly consists of a circular rod, supporting iron sheets, and a sidewall with a hole on one side, with the other side welded to a small iron sheet to support the servo motor. The solar panel is enhanced with a support rod secured with nuts and bolts, and a servo motor rotating mechanism is attached to the other side. Light Dependent Resistor (LDR) sensors are mounted on both sides of the panel [6], pointing the sun. All electronic components, including the Arduino Uno, motor driver, and buzzer, are attached to the lower portion of the solar panel by double-sided tape. The Arduino Uno is programmed with the Arduino IDE software to control the servo motor based on LDR sensor light detection and to activate the buzzer. An additional circuit is included for automatic lighting control and battery charging from the solar panel. Double-sided tape is applied to attach an LED light near the fluid tank to the solar tracker mechanism's support rod. Once all parts are assembled and electronic components are connected, all iron and steel sheets are painted to prevent corrosion.

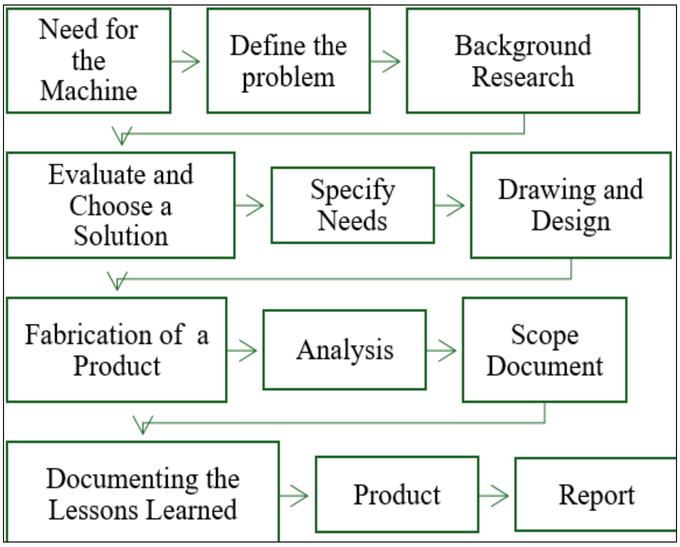

Fig 1: Process flow chart of development of mechanism

Fig 2: Label diagram of developed mechanism

Fig 3: Field test of developed mechanism

Working

The mechanism works by storing solar energy in the dynamic solar system by tracking the sun and utilizing this energy to trap the insects at night and drive away the animal using buzzers during the day. In the solar tracker system, LDR sensors were used to detect the high frequency of solar radiation and rotate the servo motor's attached solar panel based on the position of the sun. It stores 30–40% more energy than a static solar system [5, 6]. Stored solar energy is using to glow the LED light automatically at night using a self-made circuit and attract the insects of the field across the fluid tank, which will be trapped in the fluid (water). We used kerosene to reduce the surface tension of the water, by which the insects can dip in water and die. Water in a fluid tank can be drained out using a drain plug at the beneath of tank. Died insects are buried into the soil, which produces humus and increases the fertility of the soil.

Source Code

Code used in Arduino Uno to run the servo motor based on the LDR sensor and sound the buzzer for 10 minutes every hour: -

```
#include <Servo.h>
// Defining the LDR sensor pins
#define LDR1 A0
#define LDR2 A1
// Defining the error value. we can change it as we like
#define ERROR 10
// Starting point of the servo motor
int Spoint = 90;
// Defining the buzzer pin (connected to the motor driver input)
#define BUZZER_PIN 12
// Creating an object for the servo motor
Servo servo;
// Timing variables
unsigned long previousMillis = 0;
unsigned long buzzerStartMillis = 0;
const unsigned long oneHour = 3600000; // 1 hour in milliseconds
const unsigned long tenMinutes = 600000; // 10 minutes in milliseconds
void setup() {
// Attaching the servo motor to pin 11
servo.attach(11);
// Setting the starting point of the servo
servo.write(Spoint);
delay(1000);
// Setting the buzzer pin as output
pinMode(BUZZER_PIN, OUTPUT);
digitalWrite(BUZZER_PIN, LOW); // Ensuring the buzzer is off initially}
void loop() {
// Getting the current time
unsigned long currentMillis = millis();
// Getting the LDR sensor values
int ldr1 = analogRead(LDR1);
int ldr2 = analogRead(LDR2);
// Getting the difference between these values
int diff = abs(ldr1 - ldr2);
// Checking the difference using an IF condition
if (diff > ERROR) {
if (ldr1 > ldr2 && Spoint > 0) {
Spoint--; // Decrease the servo position
} else if (ldr1 < ldr2 && Spoint < 180) {
 Spoint++; // Increase the servo position}
}
// Writing the new position to the servo motor
servo.write(Spoint); delay(80);
// Checking if one hour has passed
if (currentMillis - previousMillis >= oneHour) {
previousMillis = currentMillis; // Updating the previousMillis to the current time
buzzerStartMillis = currentMillis; // Start the buzzer timer
digitalWrite(BUZZER_PIN, HIGH); // Turn on the buzzer
}
// Checking if 10 minutes have passed since the buzzer started
if (digitalRead(BUZZER_PIN) == HIGH && currentMillis - buzzerStartMillis >= tenMinutes) {
digitalWrite(BUZZER_PIN, LOW); // Turning off the buzzer}
}
```

The given setup connects a servo motor, two Light Dependent Resistors (LDRs), and a buzzer to an Arduino microcontroller (power supply from battery). The servo motor's signal line connects to digital pin 11, allowing the Arduino to control its position. Each LDR connects to an analog pin (LDR1 to A0 and LDR2 to A1), allow the Arduino to track light intensity [6]. The buzzer connects to digital pin 12, so the Arduino may activate it. These connections allow the Arduino to receive light intensity data from the LDRs, change the servo motor position, and activate the buzzer, described in code. This setup gives the flexible structure for sensor-driven control systems in fields.

Results and Discussion

After completing the fabrication of the mechanism, it was tested on two types of cultivated crops: wheat and paddy fields. In this field, static and dynamic solar system's stored solar energy is calculated in the same battery, and we found that dynamic solar systems stored more (30–40%) energy than static solar systems. During testing of this mechanism in the field, different insects were trapped in a fluid tank that was attracted by LED lights [1, 2], and all the dead insects were buried into the soil. Attached buzzer is also working and sounding 10 minutes every hour, and birds are driving away from the field by buzzer's sound.

Solar trackers were tested in the same field in both static and dynamic conditions, which gives a clear output and comparison between them [5, 6]. This test is done by discharging the battery and then charging for a particular time in both static and dynamic conditions. Weather may affect the result, but both days of the test were cleared. The output of the solar systems is tested using a multi-meter for both and a comparison between them, in which static solar systems store less energy as compared to dynamic solar systems.

Comparison between output power of static and dynamic solar system

S. No	Time	Power output (W) static condition	Power output (W) In dynamic condition
01.	11:15	1	1.35
02.	11:45	1.2	1.35
03.	12:15	1.3	1.35
04.	12:45	1.35	1.34
05.	1:15	1.4	1.32
06.	1:45	1.1	1.34
07.	2:15	0.8	1.36
08.	2:45	0.6	1.30

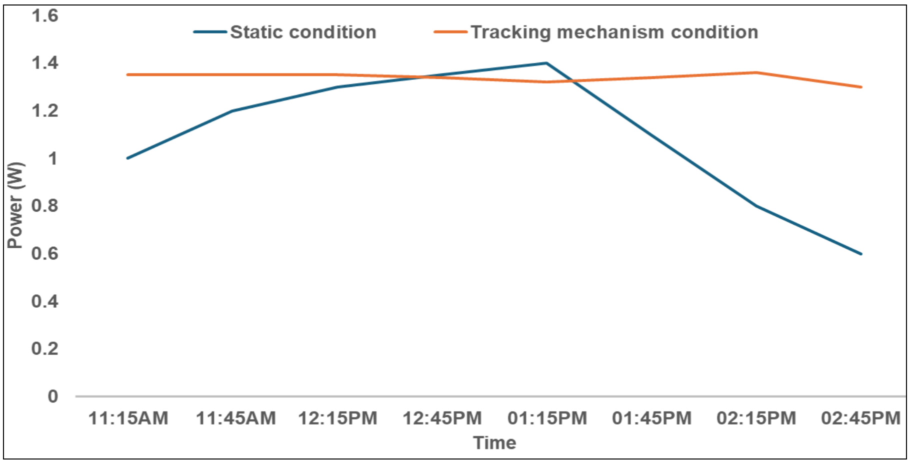

Fig 4: Comparison between static and dynamic solar

Summary and Conclusion

This mechanism uses solar energy, which has no impact on the environment and reduces the use of harmful insecticides and chemicals in crops, which cause different types of diseases in the human body. Its manufacturing cost is low as compared to insecticides and chemicals used in the field, and with a single-time investment, it has a long duration and a low maintenance cost. In this mechanism, the stand legs are 140cm; they are taken by looking at the crop's size and don't have any losses to the crop in the field. Also, lights can glow in more areas, and they can be installed at the junction of bunds in the field, which traps more insects. This mechanism is easy to handle and easy to maintain. It is the best solution for reducing the use of harmful chemicals on fields and storing more energy. This combination gives more productivity and a high yield to farmers, and crops are also chemical-free when using organic farming and this mechanism.

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