

VENUS BOT

By Rohit Ranjan, Davinderpal Singh, Sumit Sarkar, Rohit Kumar Meena, and Kanishq Sakhare

¹⁾*Indian Institute of Technology, Indore, India*

Insect infestation poses significant hygiene, health, and agricultural challenges in human environments. Conventional chemical-based insect control systems are often harmful to both humans and the ecosystem. To address this, an automated electro-mechanical insect trapping device titled “Venus Bot” is developed, inspired by the natural mechanism of the Venus flytrap. The proposed system integrates ultrasonic sensing, servo actuation, fan-based suction, and microcontroller-based control to efficiently capture both flying and crawling insects. It includes two independent **traps**: Upper trap for flying insects and bottom trap for crawling insects. Each subsystem activates selectively based on sensor feedback, performing mechanical actions such as mouth closing via hinge or rack-and-pinion systems, followed by suction into a **replaceable capture box**. The use of MOSFET-driven power management, automated closing mechanisms, and minimal-power electronics ensures safe, reliable, and continuous operation. This prototype demonstrates a chemical-free, automated, and scalable solution for **pest management in indoor, semi-outdoor and agricultural environments**. Future enhancements may include machine-vision capabilities, solar integration, and data logging for performance optimization.

Key Words: Insert luring, Detection, suction, Capturing

1. Introduction

Agricultural crops are continuously threatened by insect pests that damage leaves, stems, and produce quality. Excessive use of chemical pesticides has become a common solution, but it causes long-term soil toxicity, food contamination, pest resistance, and environmental hazard. In order to enable safer farming practices, smart and autonomous non-chemical insect control systems are needed.

Inspired by the natural mechanism of the Venus Flytrap, a carnivorous plant capable of rapidly closing its lobes using sensory triggers, this project proposes VenusBot, a biomimetic insect trapping device designed for sustainable agriculture. The device attracts pests using crop-specific luring techniques such as UV light or organic volatile compounds. Once a pest enters the trap region, ultrasonic sensing identifies its presence, triggering a rapid servo-based closing mechanism at the mouth and fan-induced suction to direct the insect into a sealed, replaceable collection chamber.

VenusBot is adjustable in height using a telescopic shaft, enabling efficient operation at different crop growth stages. The low-power electronics, simple battery operation, and containment mechanism make the device farmer-friendly, scalable, and reusable. Thus, the system offers a clean, economical alternative to pesticides, supporting higher yield and safer food production.

2. Working Principle

2.1. Attraction and Approach

The VenusBot begins by attracting insects toward the trap using a combination of UV light and natural luring elements. Flying insects are guided toward the upper trap mouth, while crawling insects naturally approach the lower entrance pathway. This stage ensures that insects are safely drawn within the sensing range of the system without the need for harmful chemicals.

2.2. Detection and Activation

As insects come close to the trap, ultrasonic sensors constantly monitor the entry region. When a flying insect is detected within the trigger distance, the microcontroller immediately commands the upper mouth to close using a servo motor, preventing escape. At the same instant, both suction fans activate and a flap inside the shaft opens, producing a strong downward airflow that pulls the insect deeper into the device. For crawling insects, an intelligent rack-and-pinion mechanism driven by two servos is activated. It lifts the lower mouth upward until it aligns flush with the upper mouth. Once alignment is achieved, the fans turn on and the crawling insect is suctioned into the internal channel just like flying insects.

2.3. Transfer and Secure Containment

After being sucked into the shaft, insects are guided into a sealed, detachable collection box fitted at the bottom. This collection box remains isolated from the main trapping chamber, ensuring hygienic handling. Once the insect enters the box, both openings close again automatically, blocking any escape routes. The suction fans then shut down to conserve battery and restore the system to standby mode, ready for the next capture.

3. Block Diagram

The system is based on an open-loop control structure. The ultrasonic sensor detects the presence of insects and sends a signal to the microcontroller. The microcontroller then activates the servo motors and the suction fan to capture and transfer the insect into the box. After the action is completed, the system resets back to its initial state without any feedback from the captured insect.

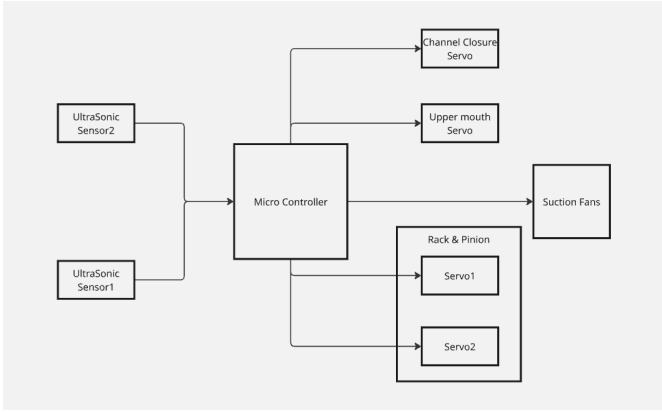


Fig. 1. Block Diagram

4. Design of Venus Trap

4.1. Upper Trap

The design draws inspiration from the two lobes of a Venus flytrap. Based on its aspect ratio, the upper trap was modeled with a transverse length of approximately 6–7 cm, allowing sufficient clearance for the ultrasonic sensor and servo mounting. The lobes are actuated using a three-gear servo mechanism. When the trap is open, a clearance of 4 cm is maintained along the ultrasonic sensor's line of sight to ensure unobstructed detection. Detection occurs only when an object crosses the sensor's line of sight within a radius of 4 cm. This connected to a telescoping shaft currently operated by wire and hole method.

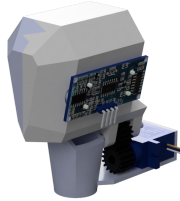


Fig. 2. Upper Trap

4.2. Capturing & Electronics Box

The capturing unit consists of two main components — a fixed box and a removable box — integrated with the electronics box for automated operation and control.

The fixed box, measuring $5 \times 5 \times 5$ cm, is permanently attached to the electronics box, which has dimensions of $10 \times 10 \times 5$ cm and includes designated input and output ports for electrical and control connections. On both sides of the fixed box, grid meshes are mounted to support two suction fans, which facilitate airflow and aid in the capture process. The removable box is designed to slide smoothly in and out of the fixed box, allowing for easy transfer and collection of captured inserts. The interface between the two boxes features rotating doors, which enable controlled passage of the insert from the fixed box to the removable one. An opening–closing mechanism is implemented in the removable box using magnets—one embedded in the operating key and another on the

rotating door—to ensure reliable and repeatable sealing during operation. Finally, the assembly includes connections between the two traps and the capturing box, completing the integrated design for efficient transfer, detection, and containment of captured inserts.

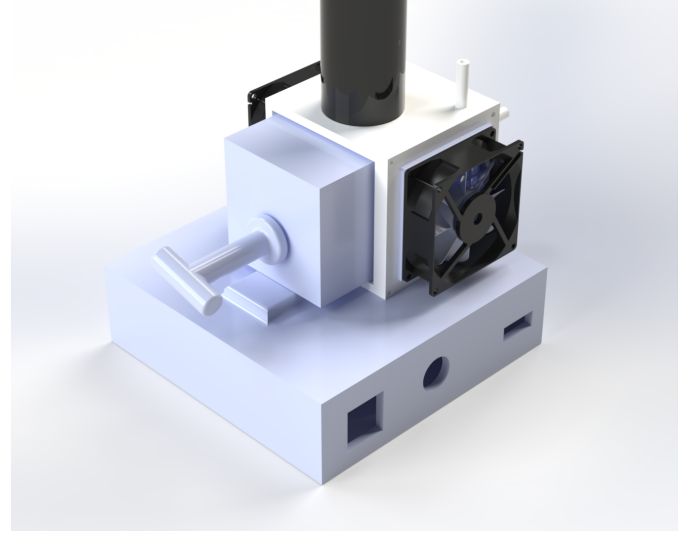


Fig. 3. Containment Box

4.3. Bottom Trap

The bottom trap is specifically designed to capture crawling insects using a rack-and-pinion arrangement for smooth base lifting. An ultrasonic sensor detects insects near the trap, triggering the microcontroller to raise the lower mouth, align with the upper trap, and activate suction fans. This sequence directs the insect into a sealed, detachable collection box for hygienic containment, with automatic closure and reset for continuous operation.

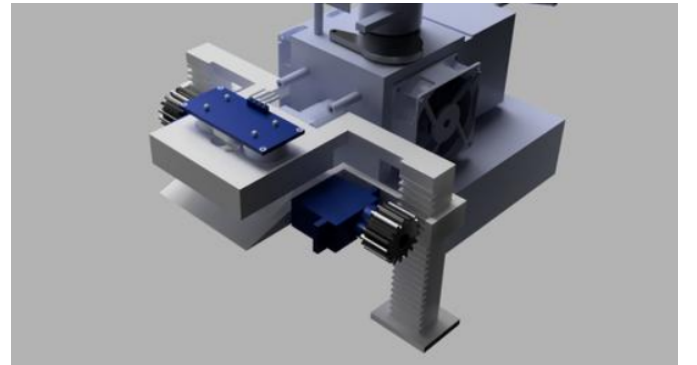


Fig. 4. Rack and Pinion Mechanism operated Lower Trap

5. Hardware Implementation

This section describes the physical integration of electronic components used in VenusBot. The hardware enables detection, actuation, and suction to carry out automated insect trapping.

5.1. Components Used

The components listed provide the electrical and mechanical functionality for the VenusBot system. The Arduino Uno serves

as the central control unit, managing the sensor inputs and actuator outputs. Ultrasonic sensors detect insect proximity, while servo motors drive the mouth closure and passage gate. The DC fans generate the required airflow to direct insects into the containment box. All components are chosen for low power consumption, compact form factor, and cost-effectiveness, making the device suitable for large-scale agricultural deployment.

The power source is a portable DC battery, ensuring that the system remains operational in remote field conditions without the need for external power supply.

Name	Quantity	Component
U1	1	Arduino Uno R3
Bat1	1	4 batteries, AA, no 1.5V Battery
M1 M2	2	DC Motor
T1 T2	2	nMOS Transistor (MOSFET)
SERV01 SERV02 SERV04 SERV03	4	Positional Micro Servo
DIST1 DIST2	2	Ultrasonic Distance Sensor (4-pin)

Fig. 5. Component Listing

5.2. Breadboard Wiring Diagram

The breadboard wiring diagram represents the initial hardware prototype assembled and simulated using Tinkercad, a virtual electronics platform that enables real-time visualization of circuit behavior. Through this digital prototyping approach, the wiring configuration could be tested before physically assembling the system, minimizing errors and reducing the chances of component damage. The ultrasonic sensors were interfaced with the Arduino's digital pins to measure distance and detect insect presence. The servo motors were supplied with a regulated 5 V power source and controlled through PWM signals, allowing precise angular movement for opening and closing of the trap mechanism. The DC fans, responsible for suction, demanded higher current and were therefore connected through MOSFET-based switching to ensure safe operation without stressing the Arduino pins. The use of Tinkercad helped us monitor signal responses, observe actuator motion, and validate the power distribution strategy. Any necessary modifications were implemented directly in the simulation, leading to a smoother transition to the real hardware. The complete breadboard prototype used for testing and validation is shown in Fig. 6.

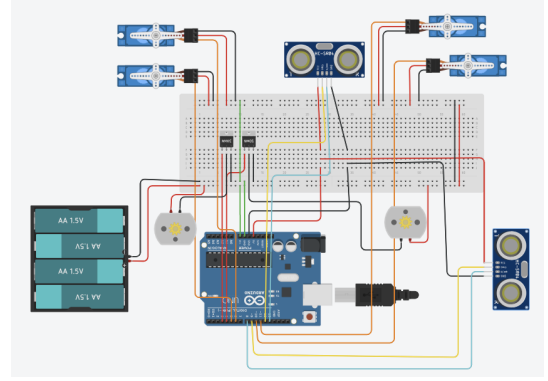


Fig. 6. Circuit Diagram

5.3. Circuit Schematic

After validating the functionality of the prototype, a refined circuit schematic was designed in Tinkercad to represent the final electrical connections in a clear and structured format. This schematic emphasizes the logical flow of signals, including power distribution, sensor interfacing, and actuator control. A common ground reference was maintained throughout the system to ensure stable operation and minimize electrical noise. The inclusion of MOSFET switches enabled reliable activation of the fans without overloading the microcontroller pins. The schematic also supports easy transition to a printed circuit board (PCB) design in future iterations. Figure 7 displays the finalized schematic layout adopted in the project.

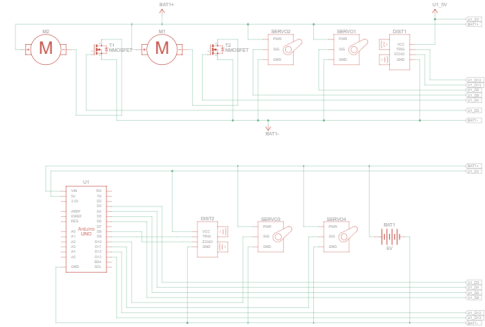


Fig. 7. Schematic View

5.4. Arduino Code Integration

Here is the Arduino control code for VenusBot's servo and sensor system. It is displayed in colorful syntax-highlighted format using the listings package.

```

1 #include <Servo.h>
2
3 // === FIRST PIPELINE ===
4 Servo servo1A;
5 Servo servo2A;
6 int trigPinA = 12;
7 int echoPinA = 13;
8 int servo1PinA = 5; //mouth
9 int servo2PinA = 6; //flap
10
11 // === SECOND PIPELINE ===
12 Servo servo1B;
13 Servo servo2B;
14 int trigPinB = 9;

```

```

15 int echoPinB = 8;
16 int servo1PinB = 11;//right
17 int servo2PinB = 10;//left
18
19 // === COMMON FANS ===
20 int fan1Pin = 3;
21 int fan2Pin = 4;
22
23 // === PARAMETERS ===
24 int thresholdDistance = 4; // cm for upper mouth
25 int tD=3;//cm for lower mouth
26 unsigned long activeDuration = 5000; // ms (5 s)
27
28 // === TIMING + STATES ===
29 unsigned long activeStartA = 0;
30 unsigned long activeStartB = 0;
31 bool systemActiveA = false;
32 bool systemActiveB = false;
33
34 // === FUNCTION TO GET DISTANCE ===
35 long getDistance(int trigPin, int echoPin) {
36     digitalWrite(trigPin, LOW);
37     delayMicroseconds(2);
38     digitalWrite(trigPin, HIGH);
39     delayMicroseconds(10);
40     digitalWrite(trigPin, LOW);
41
42     long duration = pulseIn(echoPin, HIGH, 30000);
43     long distance = duration * 0.034 / 2;
44     return distance;
45 }
46
47 void setup() {
48     Serial.begin(9600);
49
50     // FIRST PIPELINE
51     pinMode(trigPinA, OUTPUT);
52     pinMode(echoPinA, INPUT);
53     servo1A.attach(servo1PinA);
54     servo2A.attach(servo2PinA);
55     servo1A.write(0);
56     servo2A.write(55);
57
58     // SECOND PIPELINE
59     pinMode(trigPinB, OUTPUT);
60     pinMode(echoPinB, INPUT);
61     servo1B.attach(servo1PinB);
62     servo2B.attach(servo2PinB);
63     servo1B.write(0);
64     servo2B.write(0);
65
66     // COMMON FANS
67     pinMode(fan1Pin, OUTPUT);
68     pinMode(fan2Pin, OUTPUT);
69     digitalWrite(fan1Pin, LOW);
70     digitalWrite(fan2Pin, LOW);
71 }
72
73 void loop() {

```

```

74     unsigned long currentMillis = millis();
75
76     // --- READ DISTANCES ---
77     long distanceA = getDistance(trigPinA, echoPinA
78     );
79     long distanceB = getDistance(trigPinB, echoPinB
80     );
81
82     Serial.print("Pipeline A Distance: ");
83     Serial.print(distanceA);
84     Serial.print(" cm | Pipeline B Distance: ");
85     Serial.print(distanceB);
86     Serial.println(" cm");
87
88     // --- SYSTEM A CONTROL ---
89     if (distanceA <= thresholdDistance && !
90         systemActiveA) {
91         systemActiveA = true;
92         activeStartA = currentMillis;
93         for (int pos = 0; pos <= 36; pos++) {
94             servo1A.write(pos);
95             delay(15);
96         }
97         servo2A.write(0);
98     }
99     if (systemActiveA && (currentMillis -
100         activeStartA >= activeDuration)) {
101         systemActiveA = false;
102         for (int pos =36; pos >= 0; pos--) {
103             servo1A.write(pos);
104             delay(15);
105         }
106         servo2A.write(55);
107     }
108
109     // --- SYSTEM B CONTROL ---
110     if (distanceB <= tD && !systemActiveB) {
111         systemActiveB = true;
112         activeStartB = currentMillis;
113         for (int angle = 0; angle <= 180; angle++) {
114             servo1B.write(angle);
115             servo2B.write(180 - angle);
116             delay(15);
117         }
118     }
119     if (systemActiveB && (currentMillis -
120         activeStartB >= activeDuration)) {
121         systemActiveB = false;
122         for (int angle = 180; angle >= 0; angle--) {
123             servo1B.write(angle);
124             servo2B.write(180 - angle);
125             delay(15);
126         }
127     }
128
129     // --- FAN CONTROL (shared) ---
130     // Fans ON if either system is active
131     if (systemActiveA || systemActiveB) {

```

```

128     digitalWrite(fan1Pin, HIGH);
129     digitalWrite(fan2Pin, HIGH);
130 } else {
131     digitalWrite(fan1Pin, LOW);
132     digitalWrite(fan2Pin, LOW);
133 }
134
135 delay(800); // small delay for stability
136 }

```

Listing 1 Arduino code for VenusBot control

6. Conclusion

The VenusBot project successfully demonstrates a chemical-free, automated solution for pest management using a biomimetic approach inspired by the Venus flytrap. By integrating ultrasonic sensing, servo motor actuation, fan-driven suction, and microcontroller-based control, the device efficiently traps both flying and crawling insects without relying on harmful pesticides. The hardware prototype validates reliable operation in both laboratory and agricultural settings, with robust detection and trapping mechanisms. Future improvements such as machine vision, solar power integration, and data logging feature the potential for scalable deployment and further optimization. Overall, VenusBot represents a promising direction for sustainable and safe pest control in modern indoor and agricultural environments, supporting higher yields and improved food safety.

7. Future Scope

1. **Mobility with 3D-Printed Wheels** The prototype can be equipped with lightweight 3D-printed wheels at its base. This will allow farmers to manually locomote the device across the field, covering a larger area efficiently without needing multiple static traps.
2. **Intelligent Object Detection** Integration of AI-powered object detection can help the device differentiate between insects and non-target objects such as falling leaves or debris. This ensures that only pests are trapped, improving accuracy and efficiency while reducing false activations.
3. **Self-Adjustable Height Mechanism** A dynamic height adjustment system can be introduced so that the device automatically grows vertically with the crop height. This adaptability ensures that the trap remains effective throughout different crop growth stages, maximizing pest capture efficiency.