

Gower College Swansea

PROGRAM: Electrical and Electronic Engineering



Coleg Gŵyr Abertawe
Gower College Swansea

DESIGN & ANALYSIS OF MONKEY DETERRENT SYSTEM.

MODULE: DYNAMICS CONTROL & INSTRUMENTATION (GOEE4002)

Course Work Assignment

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Introduction

Human-wildlife conflict is a significant engineering and agricultural challenge for rural communities whose farmland borders wildlife habitats (Ojara, S., 2023). In Zimbabwe, the Chomzangari Women's Cooperative (Figure 1) is one such case, where monkey intrusion has reduced crop yield. For communities such as this, agriculture and livelihood are directly linked, while practical Deterrent options remain limited by cost and accessibility. Conventional methods such as scarecrows and physical patrols have proven ineffective, with the literature repeatedly identifying habituation, labour dependence and infrastructure limitations as the main barriers to long-term success (O'Brien & Hill., 2018). The Cooperative needs a solution.

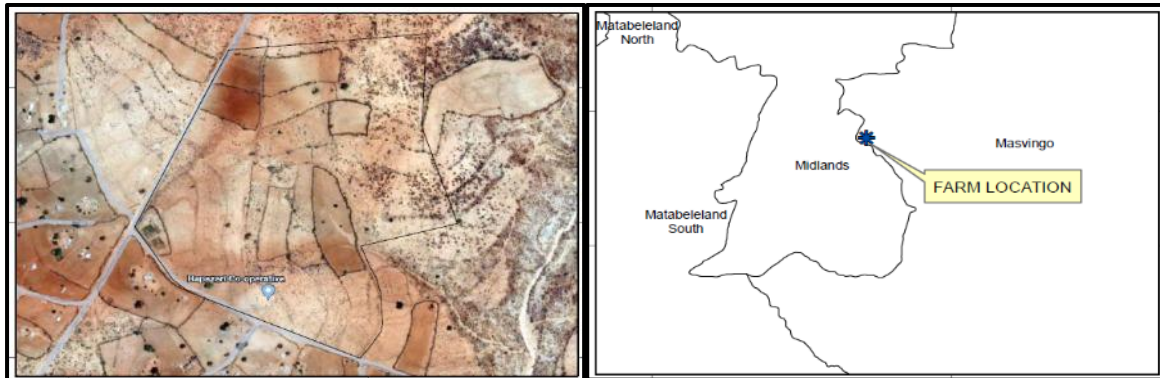


Figure 1

Analysis & Design

Assumptions and Considerations

As per the specifications outlined in GOEE4002_SEM1_CW_2025_2026 this article intends to derive a solution to the CWC with quantifiable success-metrics against conventional methods. A sustainable, scalable, low-cost, low-tech prototype, with autonomous operation – with non-kinetic and non-lethal force – should be designed and assessed as a viable solution.

(Nirala et al., 2024; Muin & Zainal, 2024) both used autonomous Deterrent approaches built around similar control equipment, including ESP32, ESP32-CAM, PIR sensing, audio output and app-linked monitoring or command functions. Their system flowcharts combined detection, control and actuation into single logic nodes. The simulation circuit diagram of (Muin & Zainal, 2024) in Figure 2 and the system flowchart from (Nirala et al., 2024) in Figure 3 are shown for reference, as their logic sequences are largely comparable.

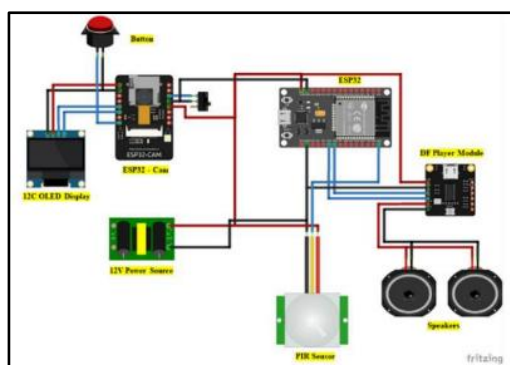


Figure 2

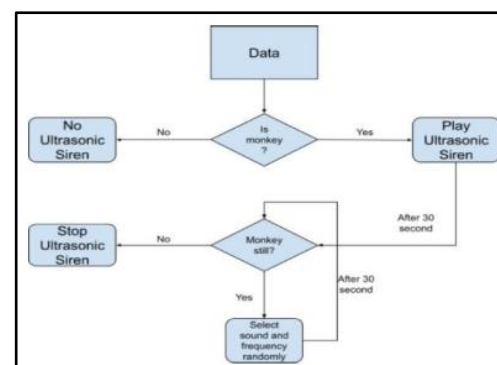


Figure 3

(Muin & Zainal, 2024) used slightly more complex hardware, mainly due to user accessibility features such as app-linking and command actuation, and both focused on monkey recognition algorithms as opposed to agnostic Deterrent efficacy, while (Nirala et al. 2024) combined ultrasonic deterrence with camera-triggered machine-learning based switching. However, although both are limited in scale and power architecture, they each demonstrated a functional prototype, rather than a proven long-duration field deployment solution. This makes them useful as a prototype references.

On the other hand, (Niloofer et al., 2025) went further by identifying intruder location, species and threat classification, but this required more advanced products and still produced technical issues and processing bottlenecks. That level of camera-based classification is not required here. Instead, the present design remains agnostic to species and uses motion confirmation, controller timing logic and staged Deterrent response as its basis of operation. In the prototype this is strengthened through an ultrasonic distance sensor acting as a secondary confirmation input, so that motion is not acted upon alone unless presence is also confirmed within a selected range.

While the design could be assembled from off-the-shelf products, budget and regional constraints remain critical. The aim is therefore not only to propose a Deterrent, but to justify a practical prototype with control logic and hardware architecture that can later be scaled through replication, improved power management and wider perimeter coverage. This distinction is important because the specifications explicitly require system analysis, modelling, simulation, I&C methodology, power supply feasibility, cost analysis, and sustainability within a real-world agricultural context. Therefore,

Costing & Budget: the specifications do not prescribe a budget, but effort will be made to source the most locally available cost-effective products.

Sustainability: This should encompass off-grid reliability, where Power design will have to be the dominant factor for sustainability; solar power is widely available, but quality products cost more if they are meant to be sustainable both environmentally and for cash flow thereafter (Electricity). This is contrary to the other components which do not necessarily increase in their sustainability factor with cost.

Maintainability & local sourcing: The specifications explicitly ask for materials readily available or easily sourced in Zimbabwe. This is a constraint as much as budget mentioned above. Yet locally sourced can generally be taken as a good indicator for local repair knowledge and spare part availability.

Scalability: Over the approximately 20ha property, there is approximately 7.5ha of crop fields and 5.5ha of paddocks. typically, assumption is that the paddocks are for livestock typically and grazing land, this would be of little interest to the monkeys, so consideration is only given for the crop fields.

Monkey Behaviour: Monkeys are highly intelligent and can differentiate between threat escalation, therefore a fixed single-mode Deterrent is likely to lose effectiveness with repeated exposure. (Teo et al., 2024). (Regmi et al., 2013) showed that crop-raiding incidence varies by crop type and reduces with increasing distance from the forest edge, indicating that monkeys make selective decisions based on energy reward and perceived risk rather than acting randomly.

Training: Farmer habits and behaviour need to be audited for a viable SOP.

What should happen

The listed assumptions and considerations are all factors affecting the control system parameters used to model the solution. Control systems exist to provide a desired response by controlling the output behaviour of devices of a system. This is achieved by managing command sequences and directing or regulating the behaviour of peripheral devices or whole systems in benefit of that desired response.

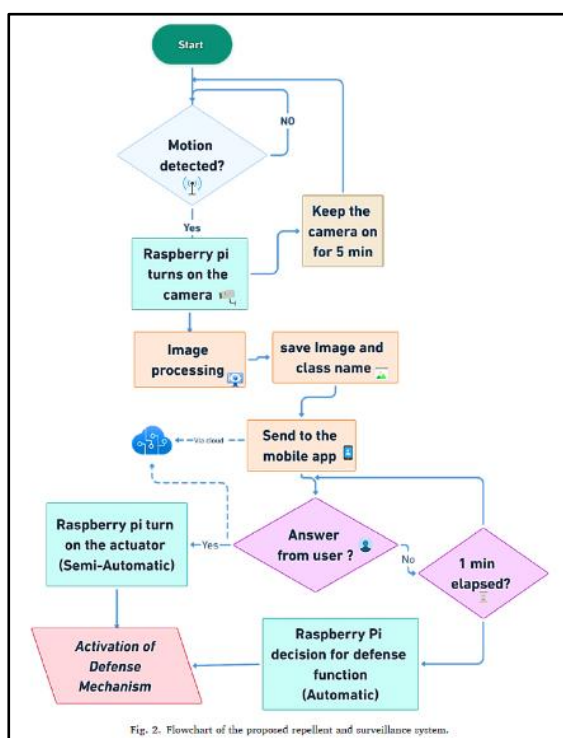


Figure 4

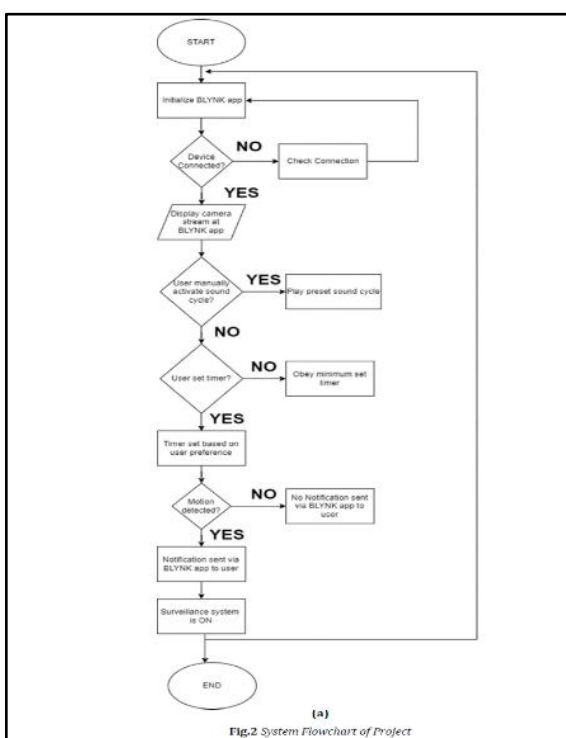


Figure 5

The requirement in this case calls for a control system where the desired response is not precision positioning or monkey threat classification, but rather fast Deterrent activation under practical field conditions with sufficient variability to reduce the monkeys interest in these crop fields “as monkeys become accustomed to the presence of the devices and lose their fear thereof”. (Ojara, S., 2023).

Figures 4 & 5 respectively (Niloofar et al., 2024; Nirala et al., 2024) show staged control logic in which sensing, controller decision and actuation are linked in sequence. However, these Figures mainly serve here as references for control architecture. For the CWC, the practical solution is an event-triggered open-loop process that remains agnostic to threat type and prioritises power sustainability over species or false-threat classification. Camera sensing is therefore unnecessary, and the prototype is simplified to PIR detection, ultrasonic confirmation, Deterrent actuation and standby reset cycles. Persistence logic is retained only to determine whether the first Deterrent stage was sufficient or whether a second stage is required before returning to standby. Examine the following:

Prototype Design Parameters

ITEM	COMPONENTS	QTY
1	SOLAR PV PANEL MONOCRYSTALLINE 30W	1
2	SOLAR CHARGE CONTROLLER MPPT	1
3	BATTERY 12VDC/7AH - GEL TYPE	1
4	ARDUINO UNO	1
5	PASSIVE INFRARED SENSOR	1
6	ULTRASONIC DISTANCE SENSOR	1
7	BUZZER/SPEAKER	1
8	FLASHER	1
9	OSCILLOSCOPE (SIMULATED ONLY)	1
10	IK & IP/NEMA RATED ENCLOSURES	1
11	METAL PLANTER ROD	1
12	CABLES, ACCESSORIES AND CONSUMABLES	LOT

Operating & Environmental Parameters

ITEM	PARAMETER	CONDITION
1	TEMPERATURE & HUMIDITY	-20-55°C (+65%)
2	WEATHER CONDITIONS	DUST, WIND, DIRECT RAIN, DIRECT SUNLIGHT
3	VANDALISM	IK20 REQUIREMENT A CONSIDERATION

Targeting Parameters

ITEM	TYPE	THREAT
1	(PEST) PRIMATES	PROJECTILES/ DIRECT ATTACK

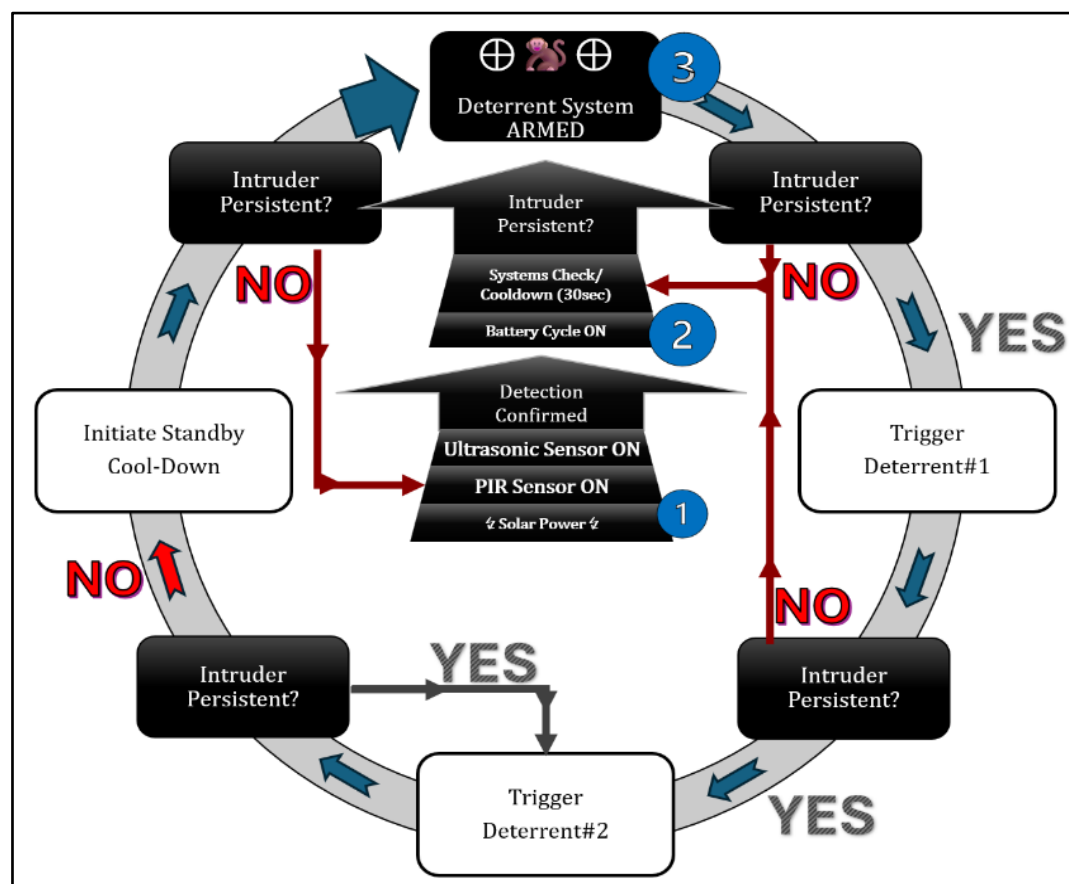


Figure 6

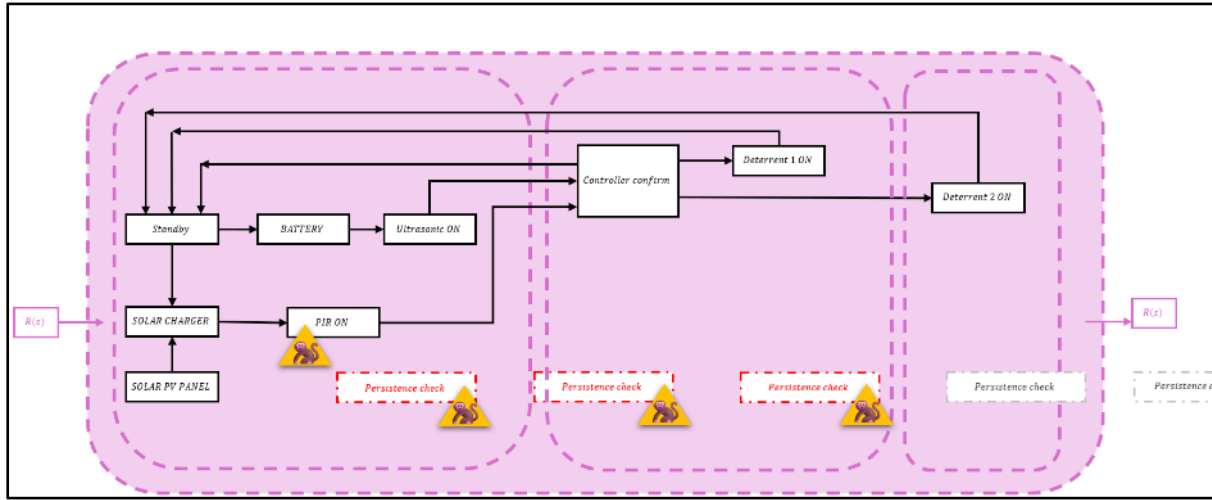


Figure 7

In control engineering terms, the proposed system is an electromechanical off-grid Deterrent process, in which monkey presence acts as the trigger input, while the controller issues a command Deterrent output through sound and light actuation. The PIR sensor provides the initial motion trigger, while the ultrasonic sensor acts as a secondary confirmation of presence within a required distance before the controller commits to the Deterrent response.

1. PIR detection signal input to the controller
2. Ultra-sonic sensor confirms to Controller to ensure that the intrusion signal is sustained, after which
3. the system checks that it remains armed and power is available before triggering the first Deterrent stage.
4. Once this cycle is complete the system resets to standby.

For the practical prototype this behaves as an event-triggered open-loop process, while the persistence checks act as decision logic within the control sequence, and guide the system back to a low-power PIR standby mode, within the response cycle once threats cease. If the intrusion remains persistent after the first response, a second Deterrent stage may be triggered before cooldown and reset. A mathematical representation of this first order response must be formulated to model the dominant delay between detection and Deterrent activation.

The measurable behaviour of the prototype is taken from the Deterrent node itself rather than from the monkey's internal decision-making process. As the rate of PIR detection-hits decrease over time, the number of Deterrent actuations of the system also decreases, because the controller is only triggered when the PIR detects motion. This is one metric; In this case, the first-order model is applied to the Deterrent node itself rather than to the monkey's behavioural decision process. The measurable performance of the prototype is based on event timing and system duty cycle, such as standby duration, detection-to-actuation delay, ultrasonic proximity confirmation, Deterrent-alarm duration, cooldown duration, and the rate of repeat trigger events.

Mathematical Modelling

(Korn & Korn, 2013) define the transfer function as the relation between the forcing function input and the normal response output and further show that where transfer-function elements are cascaded in series, the transfer functions multiply. This can be expressed as a transfer ratio (G), where:

$$G = \frac{\theta_o}{\theta_i}$$

and the variables are,

- a) the forcing function input variable, being the monkey intrusion or detection signal, expressed as the system input θ_i (θ_{in}), and
- b) the system response output, being the Deterrent activation output, expressed θ_o (θ_{out}),

but to account for the frequency response this must first be expressed by using the Laplace Transform placing it in the S-Domain for easier calculation using the algebraic representation:

$$G(s) = \frac{\theta_{o(s)}}{\theta_{i(s)}} \quad \text{or} \quad G(s) = \frac{Y(s)}{U(s)}$$

where $U(s)$ is the system input and $Y(s)$ is the system output.

Therefore

$$\begin{aligned} U(s) &= \text{disturbance input or monkey presence} \\ Y(s) &= \text{Deterrent response output} \end{aligned}$$

In this prototype, the forward path or sequence consists of the stages of sensing ($G_{1(s)}$), signal confirmation and controller decision ($G_{2(s)}$) and Deterrent actuation sequences ($G_{3(s)}$), so the overall forward path may first be represented in product as,

$$G(s) = G_{1(s)} G_{2(s)} G_{3(s)}$$

Since this behaviour is primarily a staged response process, the total forward path may be expressed using the standard first-order form:

$$G(s) = \frac{K}{\tau_s + 1}$$

Where (Korn & Korn, 2013) explain:

K = system gain

τ = time constant of the controller-actuator response

Bringing this back to the time – domain form this becomes:

$$\tau \left(\frac{dy}{dt} \right) + y(t) = Ku(t)$$

where $u(t)$ is the detection input and $y(t)$ is Deterrent output amplitude or response state.

These are the functions to be used once enough data is collected from the Simulation and prototype experiment.

Simulation & Results

Simulink Logic Verification

Simulation Testing

To proof Model Responses Simulink is used to verify the staged control logic and timing response of the proposed system at a high system level. At this stage the Simulink model verifies the staged response logic itself (ie: PIR +Ultrasonic =Deterrent 1, +Persistence =Deterrent 2).

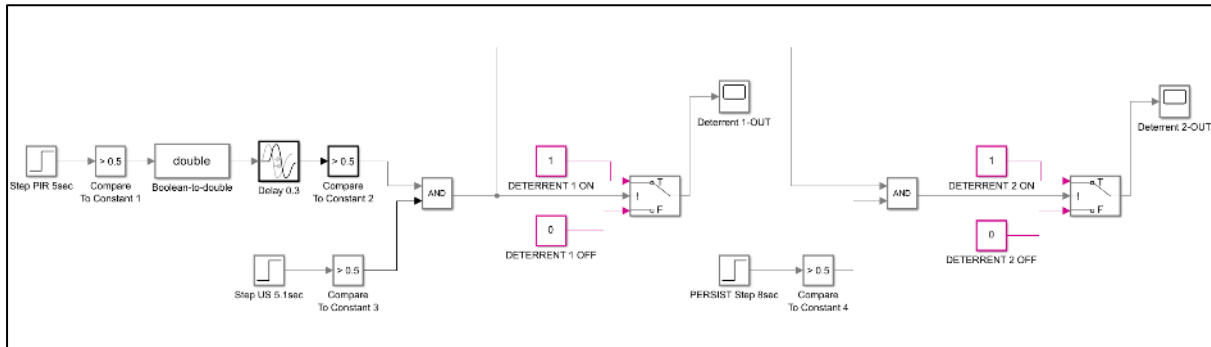


Figure 8

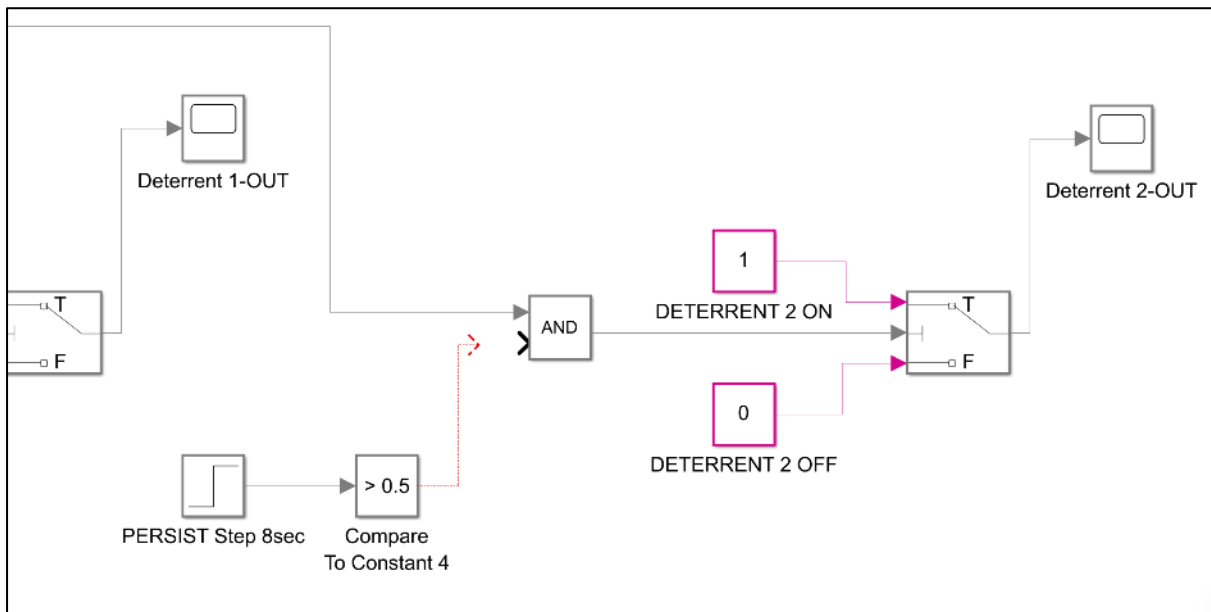


Figure 9

Simulink Logic Verification Parameters and Blocks

BLOCK	SETTINGS	PURPOSE
STEP 1	5 sec, 0→1	PIR TRIGGER
COMPARE 1	> 0.5	PIR THRESHOLD
DATA TYPE CONVERSION	double	ALLOW DELAY BLOCK
TRANSPORT DELAY	0.3 sec	CONFIRMATION LAG
COMPARE 2	> 0.5	CONFIRMED PIR
STEP US	5.1 s, 0→1	ULTRASONIC TRIGGER
COMPARE 3	> 0.5	ULTRASONIC THRESHOLD
AND 1	2 inputs	PIR + ULTRASONIC REQUIRED
CONSTANT 1	1	DETERRENT 1 ON

CONSTANT 2	0	DETERRENT 1 OFF
SWITCH 1	$u2 \geq 0.5$	TRIGGERS DETERRENT 1
SCOPE 1	30 s	SHOWS DETERRENT 1
STEP 2	8 sec, 0→1	PERSISTENCE TRIGGER
COMPARE 4	> 0.5	PERSISTENCE THRESHOLD
AND 2	2 inputs	STAGE 1 + PERSISTENCE
CONSTANT 3	1	DETERRENT 2 ON
CONSTANT 4	0	DETERRENT 2 OFF
SWITCH 2	$u2 \geq 0.5$	TRIGGERS DETERRENT 2
SCOPE 2	30 sec	SHOWS DETERRENT 2

Simulation Results

The Simulink model uses an ultrasonic confirmation input before the first Deterrent stage so that PIR motion alone is not sufficient to activate it. So the controller requires both the confirmed signals before the first Deterrent stage is allowed to actuate. This reflects the intended prototype logic, where motion and proximity are both considered before the system commits to response thereby not committing full power.

Figures 8 & 9 show the staged logic of the Simulink model under persistent intrusion conditions. The PIR trigger occurs at 5 seconds and, after the 0.3 second confirmation delay, the first Deterrent stage is activated. Since the ultrasonic confirmation is also present, the first output is allowed to pass. Where persistence remains TRUE at 8 seconds, the second Deterrent stage is then activated through the AND logic condition.

Figures 10 & 11 show the same model under non-persistent conditions. In this case, although the first Deterrent stage is still activated after confirmed PIR and ultrasonic input, the persistence condition is FALSE at 8 seconds, therefore the second Deterrent stage does not activate. This shows that the model responds correctly to both scenarios and that the escalation logic operates as intended.



Figure 10



Figure 11

Simulation Testing 2: TinkerCAD Prototype Implementation

Simulation Testing

TinkerCAD is used for prototyping PIR detection, controller confirmation, first Deterrent activation, persistence check and cooldown reset. Figures 12 & 13 show the completed prototype in both assembled and schematic form. For the purpose of the test parameters the time from first detection being $G(s)$ to Deterrent activation cycle has been set to 8sec, PIR $G_1(s)$ is triggered at 5seconds with a delay at 0.3sec $G_2(s)$. then additional confirmation by ultrasonic distance sensor at 5.1 seconds $G_3(s)$. This allows for the system to be seen in a small scale for its output state.

TinkerCAD Verification Parameters and Components

ITEM	COMPONENT	PURPOSE
1	ARDUINO UNO	MAIN CONTROLLER
2	PIR SENSOR	INTRUSION SIGNAL
3	ULTRASONIC SENSOR	CONFIRMS INTRUSION SIGNAL (TUNEABLE)
4	LED	DETERRENT FLASHING OUTPUT
5	220 Ω RESISTOR	LIMITS CURRENT THROUGH THE LED
6	PIEZO BUZZER	DETERRENT BUZZER OUTPUT
7	BREADBOARD	TEMPORARY PROTOTYPE WIRING
8	JUMPER WIRES	BETWEEN COMPONENTS
9	SERIAL MONITOR	(OPTIONAL) STATUS/DEBUGGING/PARAMETER ADJUSTEMENT

ITEM	COMPONENT	COMPONENT SIDE	ARDUINO SIDE
1	PIR SENSOR	VCC	5V
2	PIR SENSOR	GND	GND
3	PIR SENSOR	OUT	D2
4	ULTRASONIC SENSOR	VCC	5V
5	ULTRASONIC SENSOR	GND	GND
6	ULTRASONIC SENSOR	TRIG	D6
7	ULTRASONIC SENSOR	ECHO	D7
8	PIEZO BUZZER	POSITIVE (+)	D8
9	PIEZO BUZZER	NEGATIVE (-)	GND
10	LED	ANODE (LONG LEG)	D9
11	LED	CATHODE (SHORT LEG)	220 Ω RESISTOR
12	220 Ω RESISTOR	OTHER SIDE	GND

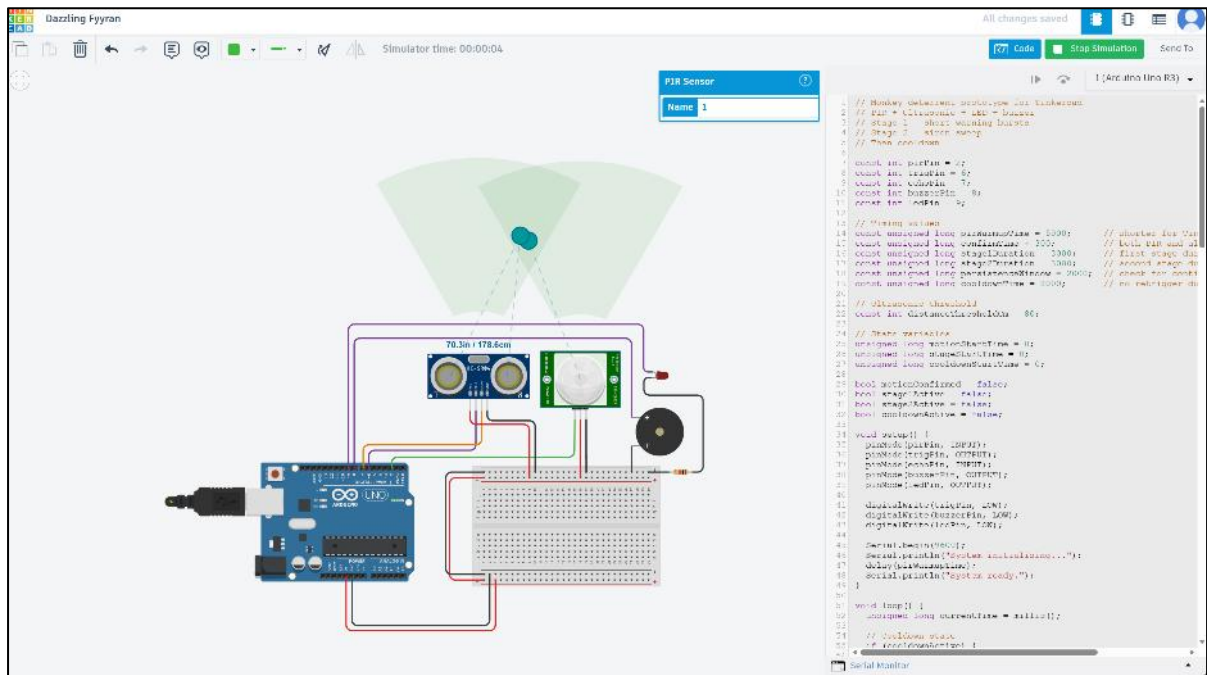


Figure 12

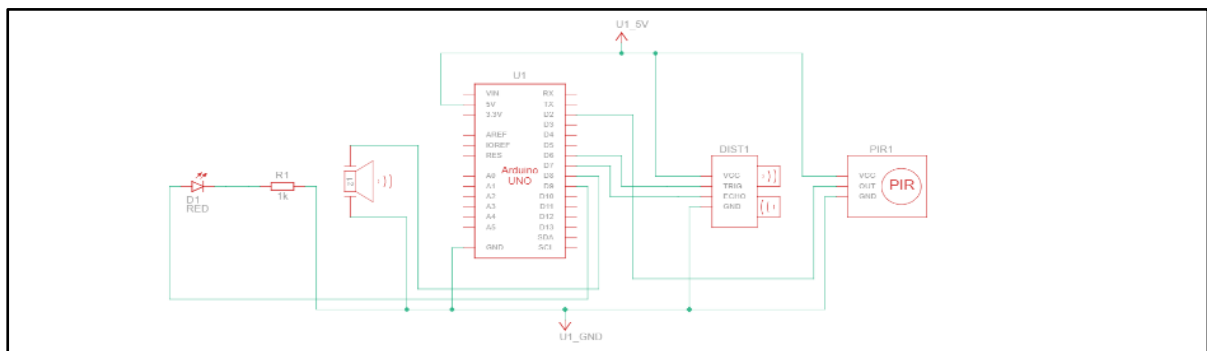


Figure 13

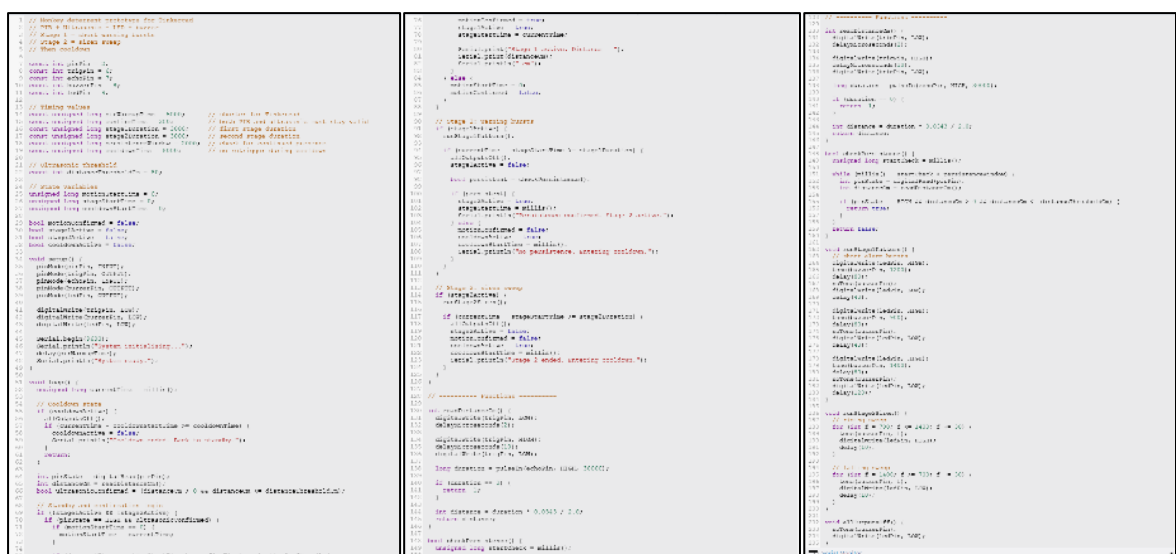


Figure 14

TinkerCAD results

The TinkerCAD prototype demonstrated the practical control logic of the Deterrent system as intended. This confirmed that the simulation remained consistent with the design parameters. The code used for the simulation is shown in Figure 14. The Arduino remained in standby until both PIR motion detection and ultrasonic proximity confirmation were satisfied, at which point the first Deterrent stage was activated. This confirms that the practical prototype reproduced the same staged logic behaviour previously verified in Simulink, while also improving trigger reliability through the addition of ultrasonic confirmation. In practical terms this makes the operation cycle more dependable than a single-sensor trigger, because the controller is less likely to waste power on weak or incomplete detections.

Below are the experimental outcomes under different sensing conditions together with their serial monitor responses.

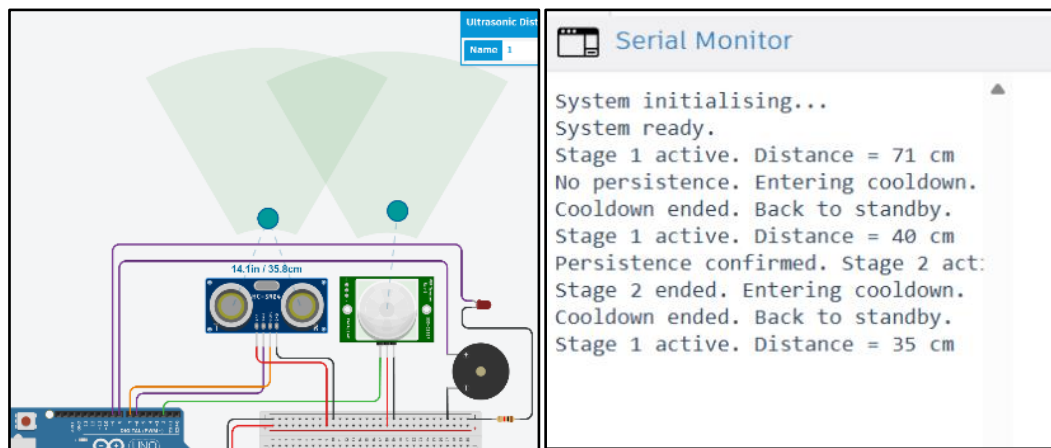


Figure 15

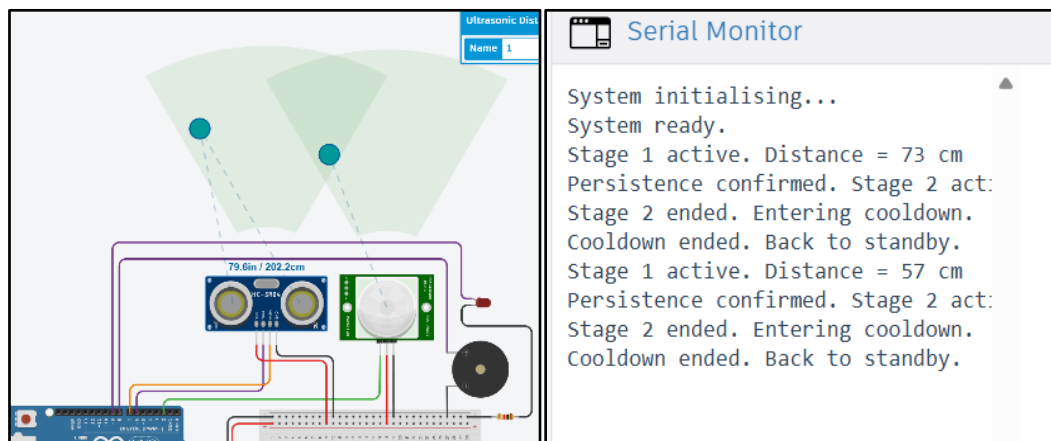


Figure 16

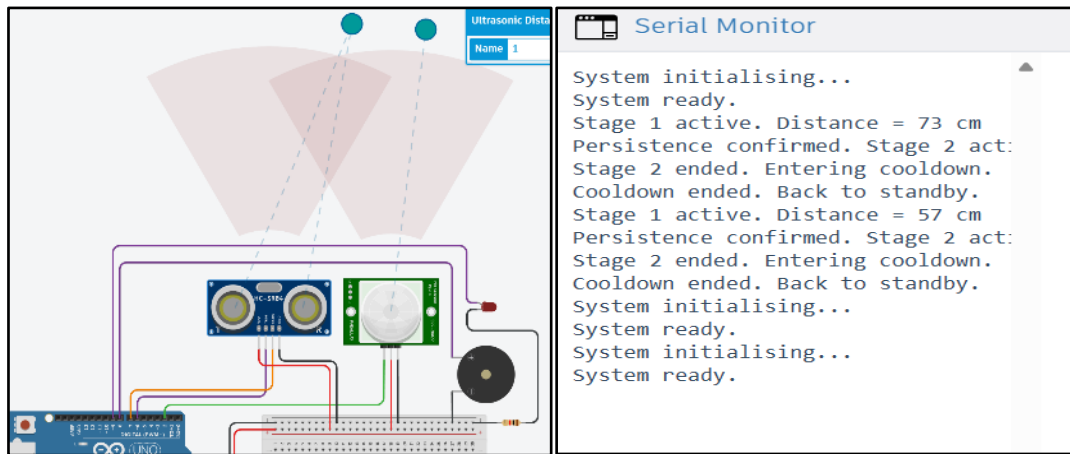


Figure 17

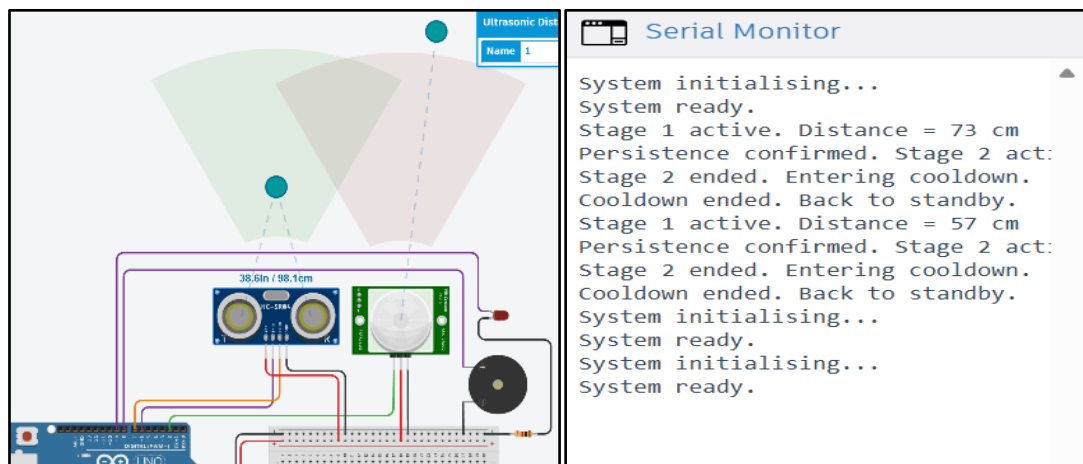


Figure 18

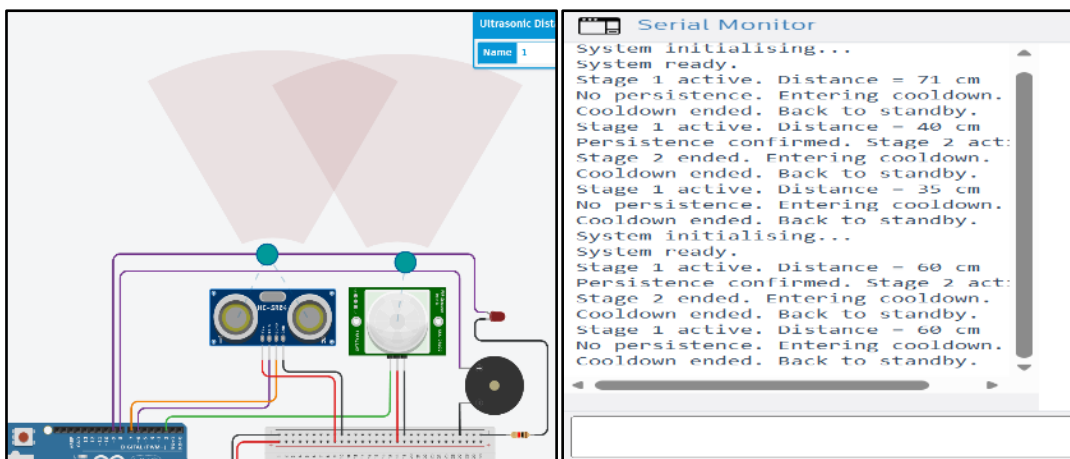


Figure 19

Considering the actual size of the instruments and components used in the simulation, and for discussion purposes an approximate scale of 1:10 has been applied such that 1cm in the prototype is treated as approximately 10cm in a practical field equivalent.

Figure 15 shows a mixed sequence in which the first valid detection at 71 cm proceeds only to Deterrent 1 before returning through cooldown, while a later confirmed detection at 40 cm proceeds to Deterrent 2 after persistence is recognised, which is the optimal condition.

Figures 16 & 17 show persistent cases, where valid detections at approximately 73 cm and 57 cm proceed through Deterrent 1, persistence confirmation, Deterrent 2 actuation and cooldown reset.

Figure 18 shows a similar persistent response at 73 cm and 57 cm, followed by system re-initialisation and return to ready state.

Figure 19 shows the widest operating range, with the controller recording both non-persistent and persistent intrusion states at different confirmed distances, including 71 cm, 40 cm, 35 cm and 60 cm, and responding accordingly with either cooldown only or full escalation to the second Deterrent stage.

Taken together, these Figures show that the Deterrent cycle is selective and repeatable, and more dependable than a simpler single-sensor trigger because the controller only commits further Deterrent output where the intrusion remains both confirmed and sustained.

Discussion/Evaluation

Does this system work?

The simulations and prototype results show that the proposed operation cycle is practical, selective and comparatively sustainable for the CWC brief. In Simulink Figures 7 & 8 show the PIR trigger occurs at 5.3sec (to include the 0.3sec confirmation delay), then both through AND logic trigger Deterrent 1. Persistence is observed to remain true at 8 sec, Deterrent 2 is then triggered through the AND logic condition. Figures 10 & 11 show that without the persistence checks the system does not escalate past Deterrent 1.

This same logic was reproduced in TinkerCAD, where PIR and ultrasonic confirmation had to both be triggered before the controller committed to output, and where the system either returned to cooldown after Deterrent 1 or escalated to Deterrent 2 depending on target persistence. In sustainability terms this is one of the stronger features of the design, because unlike the more complex referenced systems, this prototype does not waste sensing, processing or Deterrent energy on every weak trigger. It only commits further output where the intrusion remains both confirmed and sustained. That makes the cycle more convenient for low-cost field deployment, simpler to maintain, and easier to scale by replication even if it is less advanced in classification compared to the other researchers.

Additionally, the mathematical model as deduced from (Korn and Korn, 2013) can now be applied as mentioned in the design section. Applying the first-order model to the measured response gives the simplest practical representation as:

$$G(s) = \frac{1}{0.3_{sec} s + 1}$$

Where the normalised triggering point of Deterrent 1 is $K \approx 1$ at $\tau = 0.3\text{sec}$ is taken from the confirmation delay of the PIR and ultrasonic sensor. This shows that the system response observed in simulation and prototype testing is consistent with the mathematical model.

OUTPUT	ACTIVATION	BASIS
DETERRENT 1-OUT	5.3 S	5.0SEC PIR STEP INPUT + 0.3SEC CONFIRMATION DELAY 5.1SEC ULTRASONIC STEP INPUT (NO DELAY NEEDED INSIDE 5.3SEC LIMIT)
DETERRENT 2-OUT	8.0 S	PERSISTENCE STEP INPUT SATISFIED AND 'AND' CONDITION BECAME TRUE

ROM - Costing

PROTOTYPE	BRAND	REAL-LIFE ITEM	PART NO.	QTY	PRICE
ARDUINO UNO	WAVESHARE	INDUSTRIAL CONTROLLER	ESP32-S3-ETH-8DI-8RO	1	£60
PIR SENSOR	GENERIC	OUTDOOR PIR DETECTOR	12V OUTDOOR PIR SENSOR	1	£10
ULTRASONIC SENSOR	GENERIC	ULTRASONIC SENSOR	JSN-SR04T	1	£15
PIEZO BUZZER	PYLE	HORN SPEAKER	PHSP131T	1	£55
PIEZO BUZZER	GENERIC	60W AMPLIFIER MODULE	TPA3118 MONO 60W	1	£45
SOLAR PANEL	RENOGY	SOLAR PANEL	100W 12V MONO PANEL	1	£60
MPPT+INVERTER	EPEVER	MPPT+INVERTER	TRACER 2210AN	1	£60
12V/7ah BATTERY	GENERIC	LIFEPO4 BATTERY	12V 10AH LIFEPO4	1	£30
BREADBOARD	GENERIC	IP68 ENCLOSURE	GRP ENCLOSURE	1	£80
TOTAL Approx.					~£415

***BATTERY SIZE IS CALCULATED BASED ON OPTIMAL CONDITIONS

***PRICE IS INCLUSIVE OF INSTALLATION & TRAINING CHARGES

***WARRANTY: 1 YEAR

Conclusion

In conclusion, the proposed monkey Deterrent prototype satisfies the main engineering aim of producing a low-cost, scalable and defensible control solution for the CWC. The literature review showed that more advanced systems already exist, but also that these tend to rely on greater hardware complexity, heavier processing demand and more difficult long-term field maintenance. For that reason, the final design deliberately remained agnostic to species and instead focused on dependable staged logic using PIR sensing, ultrasonic confirmation, timed controller checks and two-stage Deterrent actuation. The Simulink model verified the response sequence theoretically, while the TinkerCAD prototype showed that the same sequence could be implemented in a practical form with standby, confirmation, escalation, cooldown and reset behaviour. Taken together, these results show that the design is not only functional, but selective and sustainable in how it commits power and output.

The price presented for a real world rugged and reliable system would look a little like the ROM presented above. Although this is an experiment rather than a full perimeter-wide deployment, it provides a strong engineering basis for future upscaling, node replication and sustainable power architecture.

References

Referenced Sources

- Abed, N., Murugan, R., Deldari, A., Sankarannair, S. and Ramesh, M.V. (2025) 'IoT and AI-driven solutions for human-wildlife conflict: advancing sustainable agriculture and biodiversity conservation', *Smart Agricultural Technology*, 10, p. 100829. doi:10.1016/j.atech.2025.100829.
- Korn, G.A. and Korn, T.M. (2013) *Mathematical handbook for scientists and engineers: definitions, theorems, and formulas for reference and review*. New York: Dover Publications.
- Muin, A. and Zainal, M.S. (2024) 'An IoT based monkey Deterrent for plantations with surveillance system: a method for damage control done by monkeys in plantations', *Progress in Engineering Application and Technology*, 5(1), pp. 114–121. doi:10.30880/peat.2024.05.01.012.
- Nirala, N.K., Yaduvanshi, R., Kumar, A., Bhushan, S., Bansal, U. and Ali, W. (2024) 'Design and development of ultrasonic fencing for human-animal conflict avoidance', *Grenze International Journal of Engineering and Technology*, June issue, pp. 5584–5590.
- O'Brien, E.P. and Hill, C.M. (2018) 'Assessing the potential of non-harmful, natural feeding Deterrents tested on captive primates', *International Journal of Pest Management*, 64(1), pp. 59–65. doi:10.1080/09670874.2017.1308580.
- Regmi, G.R., Nekaris, K.A.I., Kandel, K. and Nijman, V. (2013) 'Crop-raiding macaques: predictions, patterns and perceptions from Langtang National Park, Nepal', *Endangered Species Research*, 20, pp. 217–226. doi:10.3354/esr00502.
- Teo, C.L. (2024) 'Development of a greener monkey repellent: fermentation-derived biological communication method for wildlife management', *Journal of Emerging Technologies and Industrial Applications*, 3(2), pp. 1–5.
- Ojara, S. (2023) *Remotely controlled monkey repellent system*. Dissertation. Busitema University.