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Collar GPS Tracking System Using GSM Module for Elephant Detection

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Abstract

Wildlife conservation has emerged as a critical global concern in recent years. Among this wildlife conservation, elephants play a critical role in ecosystem dynamics and are particularly vulnerable to threats such as habitat loss, poaching, and human-wildlife conflicts. To solve the human-elephant conflict, a prototype for collar GPS tracking using GSM module was being developed by connecting Neo-6m GPS module and GSM module SIM900A. SMS notifications will be sent to the designated contacts when the prototype reaches certain coverage. These notifications will assist the authorities to act towards the elephants. In future, the collars can interpret the movement patterns and elephant behavior to take precaution.

1. Introduction

Cellular GPS collars, also denoted to as GSM/GPRS collars, employ cellular networks to broadcast position data [1]. These collars typically necessitate a subscription plan and contain a SIM card for network access [2][3]. Cellular GPS collar proposes wide coverage compared to other collar types, dependent on cellular network obtainability. Effective communication between the collar and users is a vital aspect of cellular GPS collars [96]. By utilizing the cellular network, the collar relays GPS coordinates to a server or cloud platform [98]. This enables users to access real-time location data through various means such as mobile apps or web interfaces [4].

In cellular communication systems, the gap between the base station and the subscriber equipment is restricted. If this distance cannot be truncated, it is advised to attach a repeater to enhance the range using a location sensing technique, such as GPS [100]. By figuring out the coordinates of the repeater and the base station, the distance between them may be estimated [5].

In remote areas lacking infrastructure and connectivity, real-time data transmission or data retrieval becomes even more challenging. To address these limitations, innovative and cost-effective tracking systems are needed to provide accurate and continuous monitoring of elephants. Leveraging advancements in wireless communication technologies and low-power solutions holds promise for developing tracking systems that are energy-efficient, scalable, and capable of long-term monitoring. One such technology is GSM Module Technology [6].

1.1 Dietary food for elephant's consumption

Elephants had a lot of demand for food. These animals usually consume as much as 150kg of food per day and large home ranges. These foods will determine the movement pattern and its behavior. This creature will look out for food even it is far from their current habitat if their current habitat does not contain sources of food anymore[7]. These food habits of the elephants had been identified through three different forest which is primary forest, selectively logged forests, and the roadside. There are various foods that were being consumed by the elephants. Table 1 below indicates the food that was consumed and its benefit.

Table 1 *Type food consumed by the elephants and its nutrition.*

Type of foods consumed by elephants	Nutrition	References
Bamboo *(Bambusa spp., Dendrocalamus sp., Schizostachyum sp.)*,	High carbohydrate	[13]
Tree bark	High protein, mineral, and fibre	[13]
woody plant *Aporosa sp. (Euphorbiaceae)*	High nitrogen	[13]

1.2 The behavioural patterns exhibited by an elephant when experiencing hunger

Crop depredation by wild elephants is a prevalent occurrence in countries within the elephant range across Asia and Africa, constituting the most frequently referenced conflict between human and elephant populations. Elephants engage in the intrusion and destruction of various cultivated crops, including vegetables, fruits, and plants. Notably, the peak period coincides with the ripening and harvesting stages of seasonal crops such as paddy or maize. While instances of damage to human property and loss of life are less frequent than crop depredation, areas near elephant habitats remain susceptible to such occurrences. Since 2008, an annual average of 225 elephants have been fatally harmed by farmers, while incidents of elephant attacks result in approximately 60-80 human casualties. Notably, data from 2017 indicates an allocation of 2.92 million for compensating human fatalities, 2.2 million for injuries, and 3.02 million for property damage croplands[8, 9].

These figures underscore the urgent need for enduring solutions, with the crucial determinant being political resolve. Consequently, communities affected by these wild elephant encounters consistently urge the government to institute effective measures. Responding to these pleas, the government has implemented the construction of electric fences as a preventive measure against wild elephant attacks. Presently, electric fencing stands as the primary solution for mitigating Human-Elephant Conflict (HEC) in Sri Lanka[10].

2. Methodology

During the selection process for developing research projects, specific components were carefully identified based on their distinct nature and intended functions. The components were Arduino Uno board, GSM module SIM900A, and Neo-6m GPS module. GSM module SIM900A was used to send notifications to the designated locations when the device enters the coverage area. Neo-6m GPS module was used to provide accurate and real-time geographical coordinates through satellite positioning, allowing for precise tracking of the device's location. Fig. 1 shows the flowchart of this project.

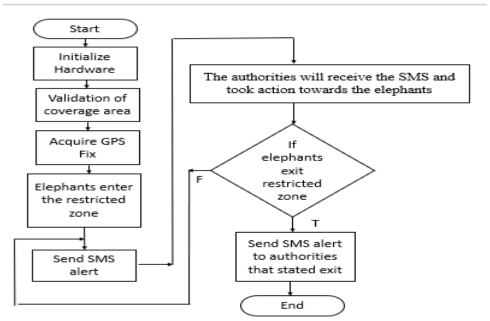

Fig. 1 *flowchart of this project*

2.1 Operation of the component

The required hardware that needed to run this project were gather which is GPS Module Neo-6m, GSM Module SIM900A, Arduino UNO Board R3, and power bank. Fig. 2 shows the connection of the component. This hardware connection will be put on the collar when it is operated at Kampung Felda Sungai Ara

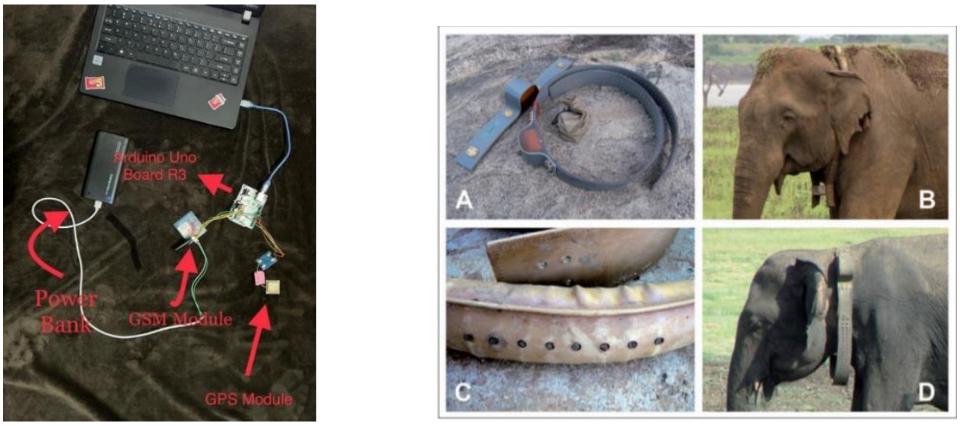

Fig. 2 *Connection of the component and the type of elephant's collar*

After the connection had been connects successfully, the latitude, longitude, and the area of the UTHM Pagoh will be identified through Google maps. The total distances covered are 1.49km and the total area

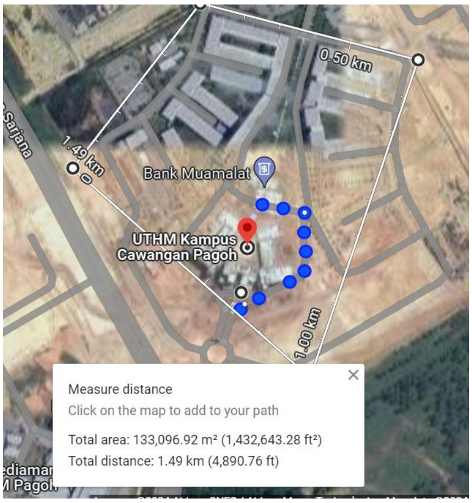

Fig. 3 Total area for UTHM Pagoh

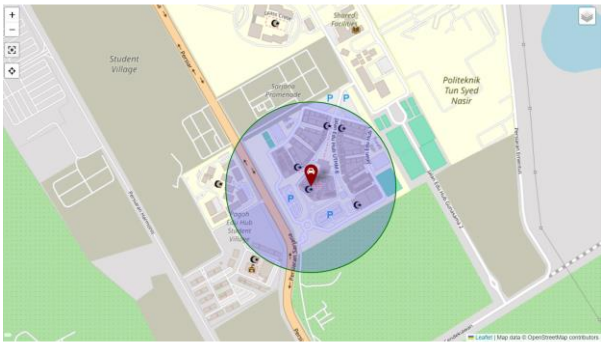

Fig. 4 *Coverage area for UTHM Pagoh*

After the area of the UTHM Pagoh had been calculated. The coverage area of UTHM Pagoh will be validate through node red dashboard.

2.2 Targeted location that will be operate this prototype.

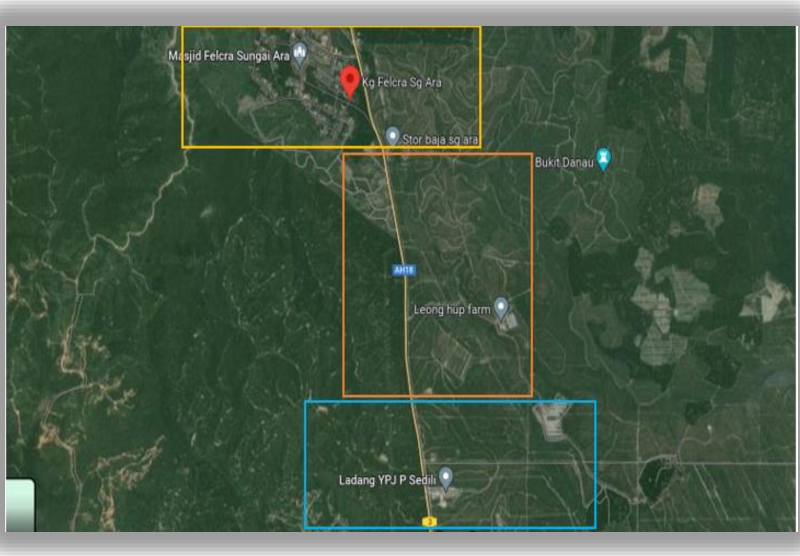

Fig. 5 *The targeted location at Kampung Felda Sungai Ara*

This prototype will be run in this area when this project was successfully completed. The area for Kampung Felda Sungai Ara will be divided into 3 zones The yellow border indicates zone A, the orange border indicates zone B, the blue border indicates zone C. This is the targeted locations that were affected by the elephants. The hardware connection will be applied on the elephant's collar later.

2.3 Operations of prototype in three different zone

This project will be tested in Pagoh's area to observe whether this project can be run later at Kampung Felda Sungai Ara. This prototype was operated in three different zone which is zone A, zone B, and zone C. By going with a car, the device was entering these three different zones at different times. The time for the SMS notifications to be received was recorded. This method was repeated 10 times by exiting and then entering the place back to get the average the time delay for all three different zone. Figure 4 below depicts the operation of the device at three different zones.

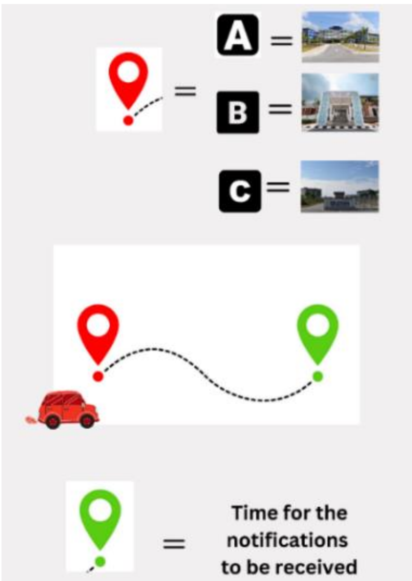

Fig. 6 *Operation of the device in three different zone*

3. Results and Discussion

In this research, the device was tested to indicate the time delay when the device had entered the zone's area. Figure below shows how the data was being collected. The stopwatch will be started to observe the time taken for the message to be send on the designated contacts when the device had entered each zone.

After the device had entered the designated area for zone A, B and C. The time delay, *t* for the SMS notification to be reach to the preferred number will be calculated. Figures 4.1, 4.2, and 4.3 show the SMS notifications only reach the preferred number after *t* = 6.45 s, 6.99 s, and 7.67 s for zone A, B, and C, respectively. This method was repeated 10 times to obtain the average time delay for the SMS notifications to be reach.

3.1 Results

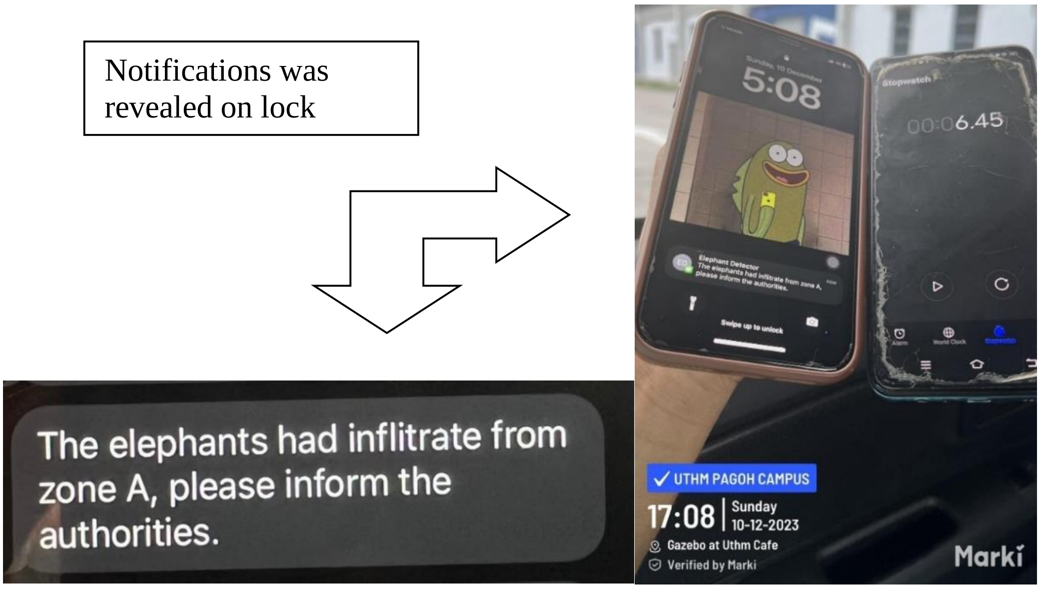

Fig. 7 *Time for the notification to be reached*

3.2 Data for the time delay for three different zone

In this section, after the coding had been verified, the hardware was being test at three different zone which is A (UTHM Pagoh), B (Masjid Muhammad Yassin), and C (Kolej Kediaman Pagoh). Table 1 shows evaluated time delay.

Table 1 *Data validation from different zone*

Measurement	Zone A(s)	Zone B(s)	Zone C
1st	9.11	7.47	7.67
2nd	8.36	8.28	9.76
3rd	6.44	9.32	8.76
4th	7.32	10.37	6.89
5th	10.47	6.27	6.42
6th	5.31	6.99	7.65
7th	8.22	6.33	9.78
8th	6.04	6.54	6.46
9th	6.45	6.62	7.89
10th	6.91	8.44	6.44
$\bar{x}$	7.463	7.663	7.772

Table 3 *Data validation from different zone*

Type of Zone	Zone A	Zone B	Zone C
S	1.572 s	1.399 s	1.295 s
%RSD	21.1%	18.3%	16.7%
$\bar{x} \pm s$	$7.142 \pm 1.572s$	$7.663 \pm 1.399s$	$7.772 \pm 1.295s$

4. Conclusion

In conclusion, this project will provide an early alert notification to the designated contacts which is the authorities. These notifications will help the villagers to take some actions in driving away the elephants outside the villagers. The current three zones were use as an indicator before it is operating at Kampung Felda Sungai Ara. The three zones were zone A (UTHM Pagoh), zone B (Masjid Muhammad Yassin), zone C (Kolej Kediaman Pagoh). The reason why three zones was chooses is to compare with three different parts from Kampung Felda Sungai Ara. The area for Kampung Felda Sungai Ara will be divided to three zones to obtain the exact place that the elephants infiltrate the villages. The time delay for the SMS notification to be send to the designated contacts was recorded. The *s* for zone A is 1.572, zone B is 1.399, and zone C is 1.295.

This will provide proactive safeguarding in detecting elephants near settlements and infrastructure enables swift actions, minimizing crop damage, infrastructure disruption, and human-elephant conflict. This GSM module will facilitate real time alert, data sharing among stakeholders, fostering collaboration between conservationists, local communities, and authorities. Moreover, the system strengthens communication between conservationists, communities, and authorities, promoting coordinated action and shared responsibility in elephant protection.

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Conflict of Interest

There is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design, data collection, methodology, analysis and interpretation of results:*** *Fadli Zulkifli, Afishah Alias and Nazirah Mohamad. All authors reviewed the results and approved the final version of the manuscript.*

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