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Determining the position and health status of camels using IoT technology

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Abstract

Many activities that required human intervention in the past are now less visible than before with the increasing advancement of information and communication technology. Many activities, whether simple or complex mental computing activities or physical activities, have given way to the world of information technology. The internet of Things is one of the cases that, in addition to helping human labor, has also caused the loss of employment for many people today. Here, we will use the Internet of Things to help with one of the difficult and dangerous jobs. Camels are one of the expensive and valuable livestock that, due to their environment conditions, sometimes require grazing in the desert areas; therefore, we cannot expect a herdsman to always accompany them. In this article, we will look at the location of camels using clustering and with the help of Internet of Thing, so that in the absence of a herdsman with the herd, we can check the location of these animals and be informed about the health of the animals. With this method, we were able to cluster the camels within 5, 10 and 20 meters of each other and inform the main server about their presence or absence in the clusters.

Introduction

The Internet of Things is an emerging topic of technical, social, and economic significance. Consumer products, durable goods, cars and trucks, industrial and utility components, sensors, and other everyday objects are being combined with Internet connectivity and powerful data analytic capabilities that promise to transform the way we work, live, and play[1]. The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. There is, however, no single, universal definition[1].

The Internet of Things (IoT) aims to expand the benefits of continuously connected internet connectivity. It enables the connection of machines, equipment, and other physical items to networked sensors and actuators to obtain data and manage their performance[2].

The smart city is critical for sustainable urban development[3]. A smart city features the utilization of information and communication technology (ICT) infrastructure, human resources, social capital, and environment resources for economic development, social/environmental sustainability, and high quality of human life[3]. There are massive moving objects in a city (e.g., humans, animals, vehicles, cargo, goods, and trash). Various kinds of ubiquitous sensors in the city can collect different types of traces of them. The trace data can then be input for mining to characterize knowledge about mobility, people, and the city. Finally, applications can exploit the knowledge mined to make them smarter in different domains of a smart city[3].

Examples of using the Internet of Things in the field of animal husbandry:

The goal of the Sheep IT project is to create a service based on the Internet of Things that will improve the monitoring and management of sheep flocks used for weeding vineyards. To do this, the system is constructed

Doi:

from a variety of modules, each with its own set of interconnected behaviours. Significant among these responsibilities is the requirement to collect data, compile that data, analyse that data, and communicate the results[4].

It is demonstrated the construction, working and deployment of a neck mounted intelligent IoT aided device called 'MOOnitor' for cattle activity monitoring inside the barn as well as in the pasture. The device is capable of recording acceleration, temperature and walking speed information of cattle and transmitting the data directly to server over SIM based GSM module. Thereafter, implementation of intelligent algorithm with the acquired information would facilitate an automated cattle activity classification. Since nature of an animal's activity is strongly related to its health and well-being, such a methodology would enable the farmers or owners to monitor the cattle in a better way[5].

Animal encroachment is causing extensive damage to agricultural lands and crops worldwide. Various technologies have already been implemented to mitigate the intrusion of animals. The integration of artificial intelligence with IoT setups has played a significant role in tackling this problem[6].

With the rapid development of wireless and embedded technologies, many new opportunities appear for monitoring and tracking mobile objects, including animals[7].

To prevent malnutrition, hunger, and thirst in stray animals, this technology has been used in a model based on distributing animal food in sufficient quantities for animals living in each area[8].

The most important aspect of a Smart Farm is the use of Internet of Things based systems to Monitor and Control the different sensor-based systems used in the farm[9].

The advancement in recent technologies provides different techniques to monitor and manage the livestock. The animal monitoring system include various features like monitoring the health level of livestock, tracking the live location of the cattle and also includes smart feeding methodology to monitor the quantity and quality of the animal feed[10].

Materials and methods

IoT consists of four layers:

- Sensor layers
- Network layer
- Data processing layer
- The app layer

Geometric analysis of the problem

As you know, the equation of a circle with radius r and center (a, b) is equal to:

$$(x-a)^2 + (y-b)^2 = r^2 \qquad (1)$$

Also, the distance between two points $M(x_1, y_1)$ and $N(x_2, y_2)$ is calculated as follows:

$$d = \sqrt{(x_1-x_2)^2 + (y_1-y_2)^2} \qquad (2)$$

Now we conclude that if a point is outside the circle, its distance from the center is necessarily greater than the radius; and if it is inside the circle, its distance is less than the radius. So, it is obvious that for a circle with radius R and center (a, b):

A. If the point (x, y) is inside the circle:

$$(x-a)^2 + (y-b)^2 < R^2 \qquad (3)$$

B. If the point (x, y) is outside the circle:

$$(x-a)^2 + (y-b)^2 > R^2 \qquad (4)$$

C. If the point (x, y) is on the radius (the boundary line or circumference of the circle):

$$(x-a)^2 + (y-b)^2 = R^2 \qquad (5)$$

Given our problem, our goal is to examine a specific radius of a point (sensor) each time. So, it's better to consider it like this:

$$(x-a)^2 + (y-b)^2 \le r^2 \qquad (6)$$

Now suppose that point A is located at coordinates (x_1, y_1). To search within a radius of r meters, we consider the search equation around sensor A as follows:

$$(x-x_1)^2 + (y-y_1)^2 \le r^2 \qquad (7)$$

And we scan the sensor surroundings with a fixed value of r.

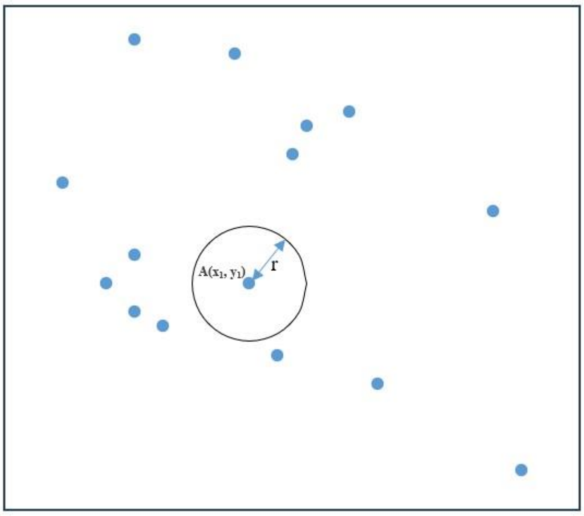


Fig 1 : Check the radius r of sensor A

Now if we consider the criterion for checking and searching around this sensor as the value $(r + \alpha_1)[Assuming\ 0 < \alpha_1]$.

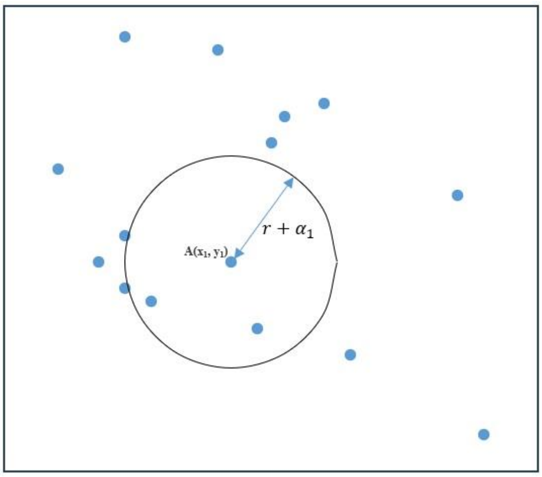


Fig 2 : Checking the radius $r + \alpha_1$

And if we assume $\alpha_1 < \alpha_2$, and consider searching around this sensor with the value $(r + \alpha_2)$, a larger range can be searched and certainly more sensors can be found.

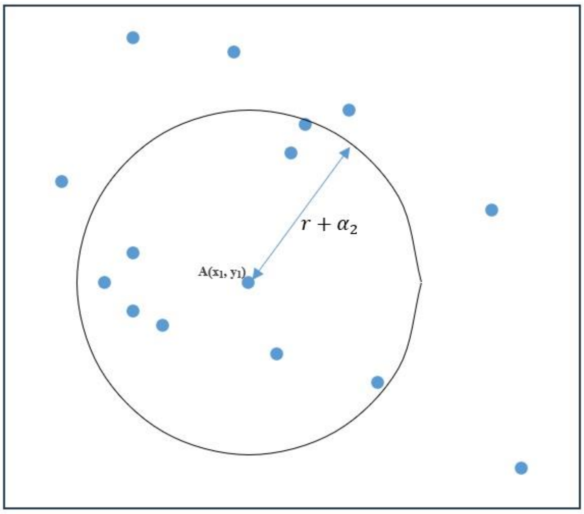


Fig 3 : Checking the radius $r + \alpha_2$

Therefore if $\alpha_1 < \alpha_2 < \alpha_3$ and we search for a fixed radius value r, we will have:

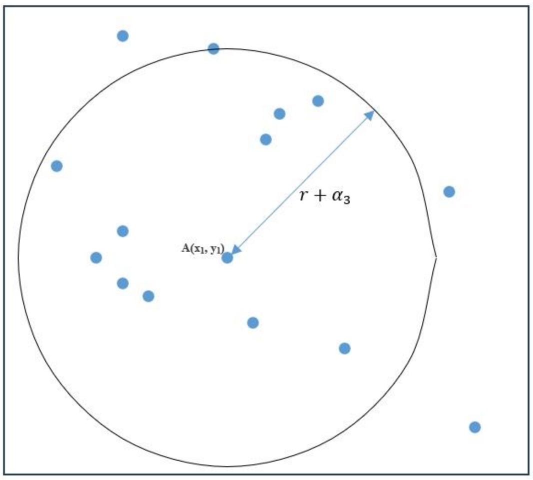


Fig 4 : Checking the radius $r + \alpha_3$

So, it is obvious that the wider and larger we consider the search, the more points we can search and the number of members in the clusters will be greater than in cases with a smaller radius; and since in this problem our goal is to check that all the camels are in a close range and did not separate from the herd; then we do not need to use very large ranges to start with. Perhaps all the members are in a close distance and there is no need for heavier and larger calculations.

Examining the problem with a base radius of 5 meters:

To understand it more clearly, let's assume that the sensors attached to the camels are random points on a coordinate axis. We consider 15 points with the following positions on the coordinate axis.

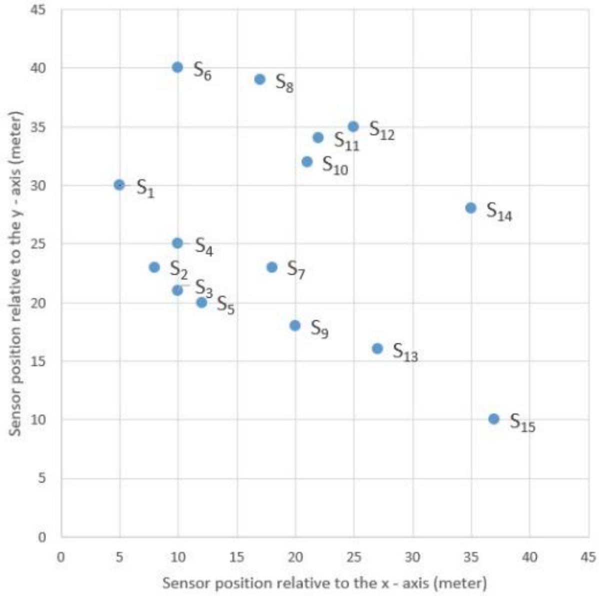


Fig 5 : Displaying the position of random points on the coordinate axis

Table 1 : Sensor location

Sensor	Location
S_1	(5, 30)
S_2	(8, 23)
S_3	(10, 21)
S_4	(10, 25)
S_5	(12, 20)
S_6	(10, 40)
S_7	(18, 23)
S_8	(17, 39)
S_9	(20, 18)
S_{10}	(21, 32)
S_{11}	(22, 34)
S_{12}	(25, 35)
S_{13}	(27, 16)
S_{14}	(35, 28)
S_{15}	(37, 10)

Then we search within the desired radius around each point:

First, we calculate the 5-meter radius of all sensors; If we find a point, in addition to clustering, after completing the search and not finding a new member, we send a message to the main server that IP_x is located around me; we also send a message to the found sensor itself that you are in my area, save my IP (so that the cluster members are aware of the group leader).

To start, we consider a variable called Mid; and we store the initial position of each sensor in it.

Table 2 : Considering the position of the sensors as the center

Sensor	Initial Location
S_1	Mid (5, 30)
S_2	Mid (8, 23)
S_3	Mid (10, 21)
S_4	Mid (10, 25)
S_5	Mid (12, 20)
S_6	Mid (10, 40)
S_7	Mid (18, 23)
S_8	Mid (17, 39)
S_9	Mid (20, 18)
S_{10}	Mid (21, 32)
S_{11}	Mid (22, 34)
S_{12}	Mid (25, 35)
S_{13}	Mid (27, 16)
S_{14}	Mid (35, 28)
S_{15}	Mid (37, 10)

Table 3 : Server table

Sensor	Initial Location
S_1	0
S_2	0
S_3	0
S_4	0
S_5	0
S_6	0
S_7	0
S_8	0
S_9	0
S_{10}	0
S_{11}	0
S_{12}	0
S_{13}	0
S_{14}	0
S_{15}	0

Geometrically, the equation of a circle with the center (a, b) and radius 5 meters is equal to:

$$(x-a)^2 + (y-b)^2 \leq 5^2$$

Now we search around each sensor and if we find a new member within the desired radius, we perform clustering:

The position of sensor S_1 is $Mid(5, 30)$, So given these coordinates, the equation of a circle with center $(5, 30)$ should follow this equation:

$$(x-5)^2 + (y-30)^2 \leq 5^2$$

As can be seen, no sensor points are found within a 5-meter radius.

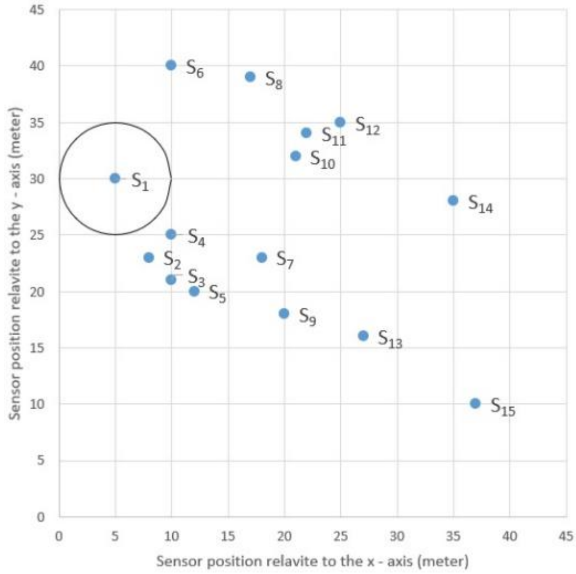


Fig 6 : Search within a 5-meter radius of the S1 Sensor

This sensor is located at coordinates $Mid(8, 23)$. Given these coordinates, the equation of a circle with this center and radius of 5-meter is:

$$(x-8)^2 + (y-23)^2 \leq 5^2$$

This sensor starts searching.

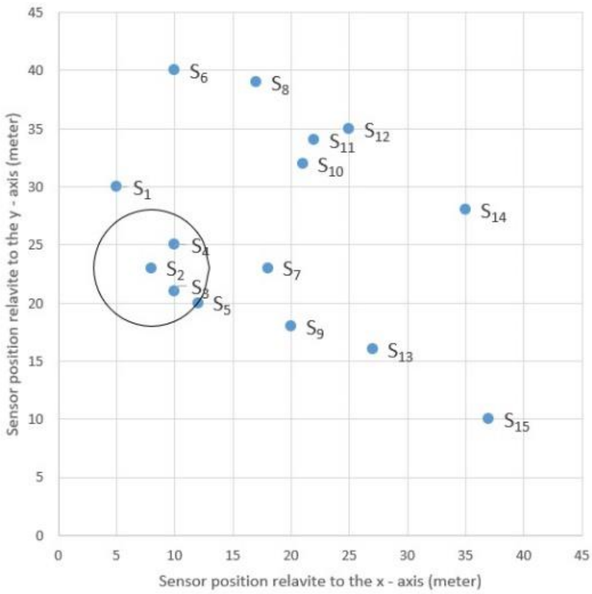


Fig 7 : Search within a 5-meter radius of the S2 Sensor

As seen in Fig.7, sensor S_2 finds three sensors S_3, S_4 and S_5 within its 5-meter radius, because the equation of a circle with a radius of 5 meters and center S_2 is true for these three sensors, and the points are located inside or on the circumference of the circle.

$$Sensor\ S_3: \quad (10-8)^2+(21-23)^2 \leq 5^2$$
$$Sensor\ S_4: \quad (10-8)^2+(25-23)^2 \leq 5^2$$
$$Sensor\ S_5: \quad (12-8)^2+(20-23)^2 \leq 5^2$$

Thus, cluster C_1 is formed.

$$C_1=\{S_2,S_3,S_4,S_5\}$$

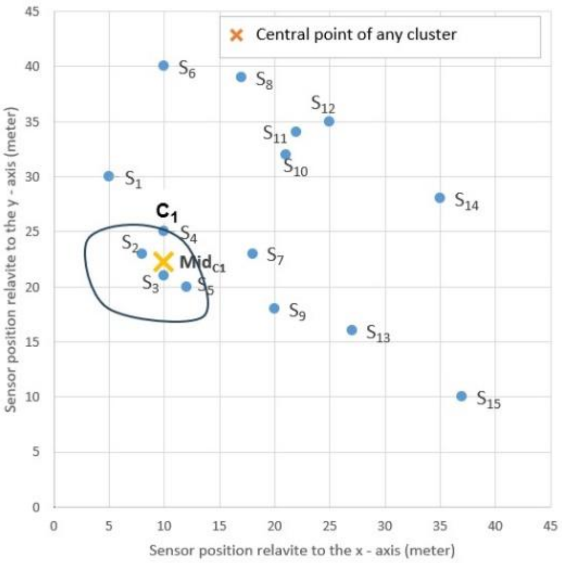


Fig 8 : Formation of cluster C1 and finding the center of this cluster

After forming cluster C_1 with respect to the four cluster members, we find the center coordinates of the cluster.

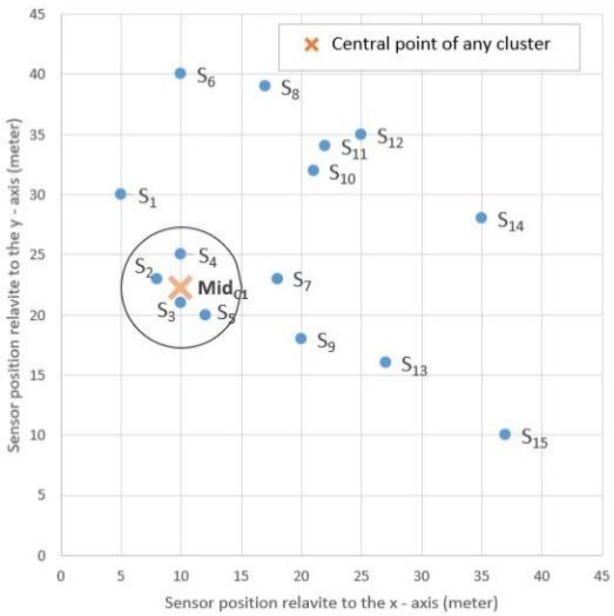


Fig 9 : Search within a 5-meter radius of the center of cluster C1

$$Mid_{C_1}\left(\frac{x_2+x_3+x_4+x_5}{4},\frac{y_2+y_3+y_4+y_5}{4}\right)$$
$$\rightarrow Mid_{C_1}\left(\frac{8+10+10+12}{4},\frac{23+21+25+20}{4}\right)$$
$$\rightarrow Mid_{C_1}(10,29.6)$$

Now, considering the center point of cluster C_1, we examine the radius of 5 meters.

According to the equation of the circle, no point can be found for this central point.

$$(x-10)^2+(y-29.6)^2 \leq 5^2$$

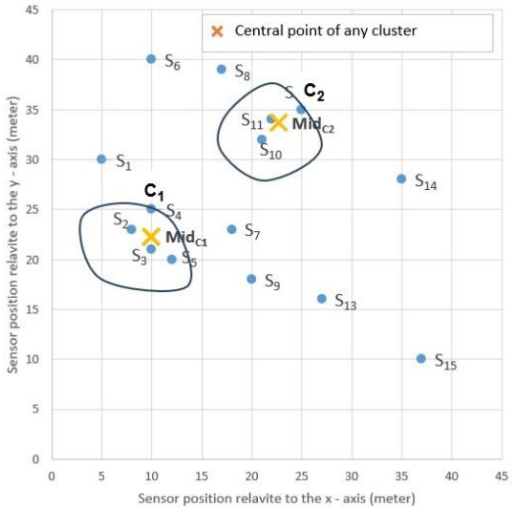
Now we have a cluster that does not allow adding new members, we need to send the points found so far in this cluster to the main cluster head(server) so that the server can check whether all IPs are clustered or not. If the sensor is clustered, the value is one otherwise it is specified with the value zero.

Table 4 : Updating the server table after checking the S2 sensor

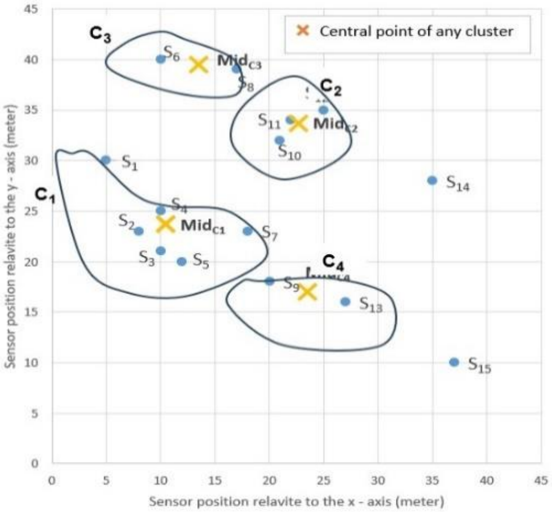
Sensor	Initial Location
S_1	0
S_2	1
S_3	1
S_4	1
S_5	1
S_6	0
S_7	0
S_8	0
S_9	0
S_{10}	0
S_{11}	0
S_{12}	0
S_{13}	0
S_{14}	0
S_{15}	0

As you can see, many IPs are still not clustered. We do this with all sensors. After checking the 5-meter radius of all sensors, if there is an unclustered sensor, we add another 5 meters to the base radius. And we continue this until all sensors are clustered or they are unable to search in a large range.

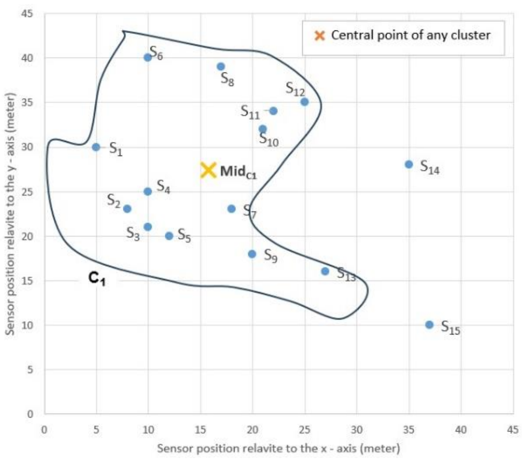
Generally, in this example, clustering with a base radius of 5 meters and a 5-meter increase in radius is as follows (a - f):



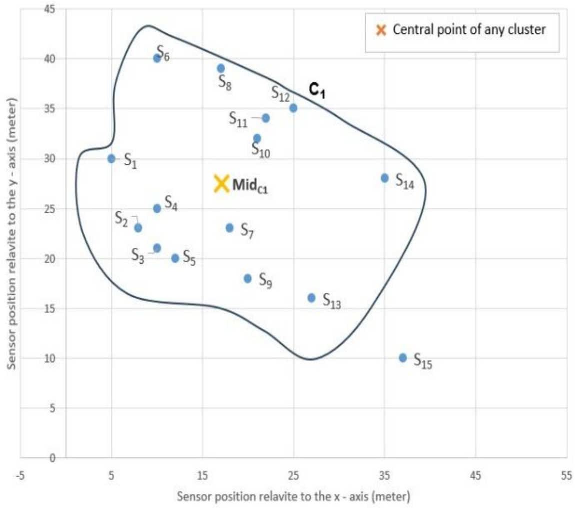
a) First stage search within a 5-meter radius



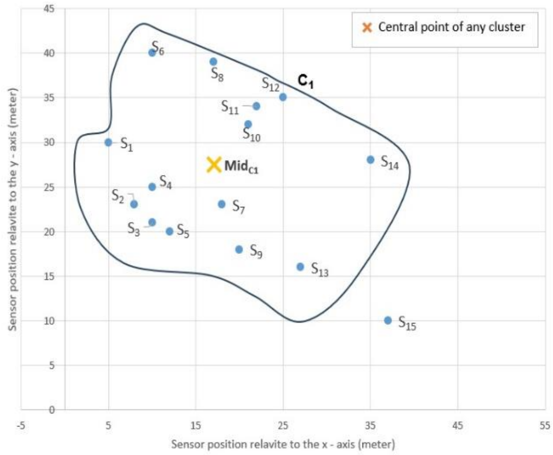
b) Second stage search within a 5-meter radius



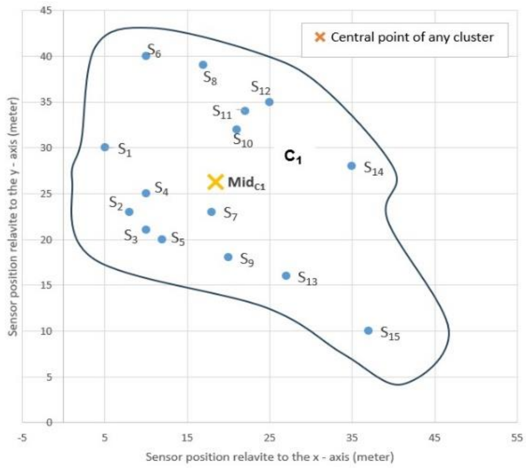
c) Third stage search within a 5-meter radius



e) Fifth stage search within a 5-meter radius



d) fourth stage search within a 5-meter radius

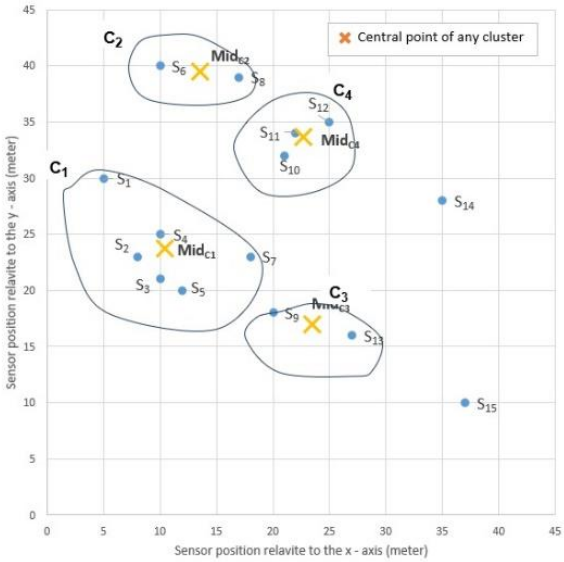


f) Sixth stage search within a 5-meter radius

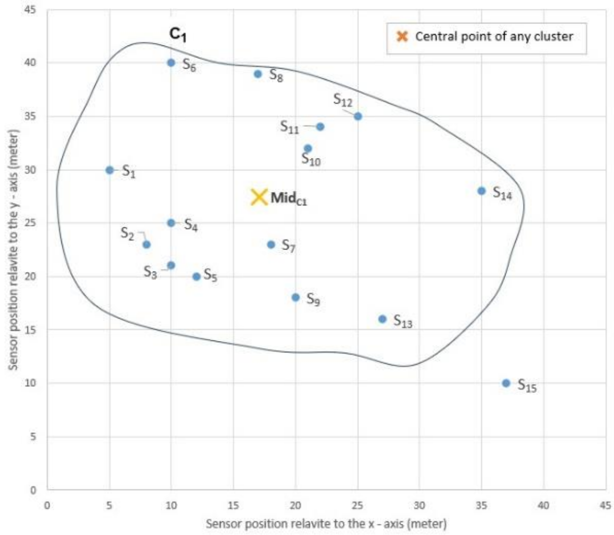
Fig 10: Fifteen random points with a base radius of 5 meters and an increment of 5 meters

Comparison of clustering with radius 5, 10 and 20 meters

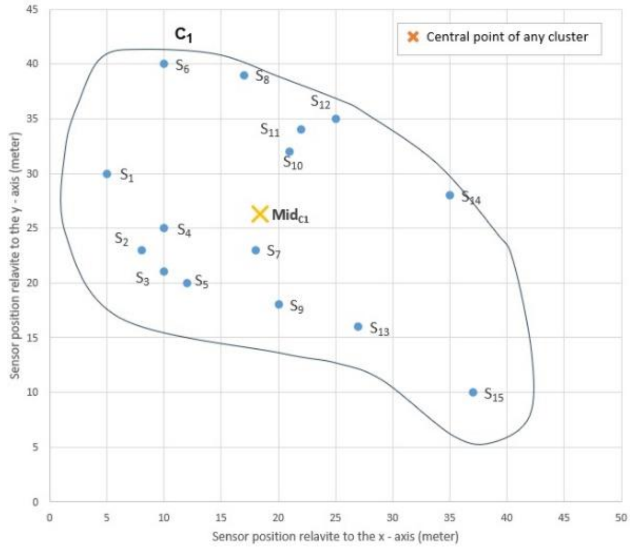
Previous example with a base radius of 10 meters and an increment of 10 meters and also with a base radius of 20 meters and an increment of 20 meters:



a) First stage search within a 10-meter radius

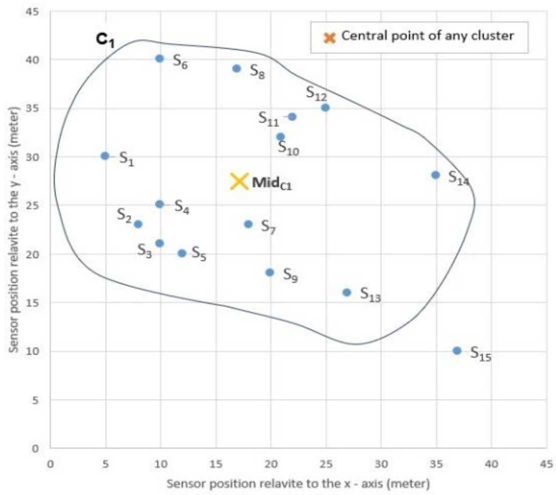


b) Second stage search within a 10-meter radius

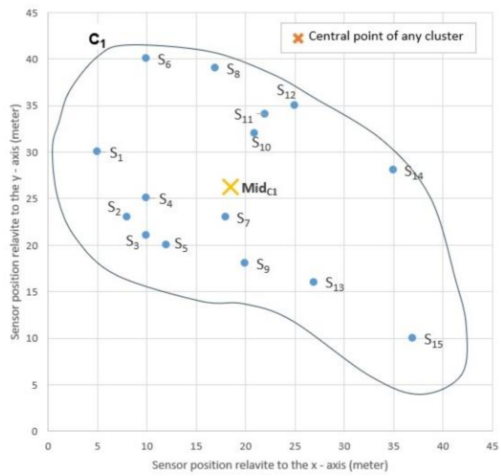


c) Third stage search within a 10-meter radius

Fig 11: Fifteen random points with a base radius of 10 meters and an increment of 10 meters



a) First stage search within a 20-meter radius



b) Second stage search within a 20-meter radius

Fig 12: Fifteen random points with a base radius of 20 meters and an increment of 20 meters

According to the comparison made for these three different scales:

Table 5 : Comparison of searches in radius of 5, 10 and 20

Desired base radius	The amount of checking each step	Number of clusters	Total steps
5 m	5 m	2	6
	10 m	4	
	15 m	1	
	20 m	1	
	25 m	1	
	30 m	1	
10 m	10 m	4	3
	20 m	1	
	30 m	1	
20 m	20 m	1	2
	40 m	1	

As can be seen, the larger the radius, the faster the livestock is found and the fewer the clusters. Depending on the goals and considering the benefit of livestock owners in terms of the cost of this product, the best decision can be made regarding the selection of the radius and searchable range.

The communication and search of these sensors can be done via a Bluetooth communication network, because it is cheap in terms of cost and has lower energy consumption; which is suitable for livestock that is not known for how many hours or days it is going to use this approach. However, it should be noted that the use of Bluetooth is possible up to a range of 100 meters.

Conclusion

One use case for IoT is to accelerate remote livestock monitoring to ensure that livestock are healthy and do not stray from the herd. If we integrate this technology with the topic of clustering, which sometimes deals with the problem of unsupervised learning, it reduces the risk of livestock damage as much as possible. One of the topics of clustering is distance-based clustering. In this study, this concept was used to cluster livestock in a herd, with the difference that each livestock that was seen by a sensor in the IoT world examined a certain radius around it, and if a sensor or the center of another cluster was within this radius of the circle or on its border, it considered it as its nearest neighbor and performed clustering with its own group leader. This search continued until we were sure that the number of livestock in the herd was clustered. If an animal gets separated from the herd and cannot be found after repeated searches, its last location can be checked from the main server.

Conflict of Interest

The authors declare that they have no conflicts of interest in relation to the publication of this research article entitled “Determining the position and health status of camels using IoT technology.” Zahra Ghalandarzadeh Dehnavi and Abbas Rezaee have no financial or personal relationships that could influence the content of this work.

References

[1] K. Rose, S. Eldridge, and L. Chapin, "The internet of things: An overview," The internet society (ISOC), vol. 80, no. 15, pp. 1-53, 2015.

[2] L. Faridah, A. U. Rahayu, R. N. Shopa, H. Sulastri, N. Hiron, and F. M. Nursuwars, "Caribi Mobile Application Based on Radio Frequency Identification (RFID) for Internet of Things (IoT)," International Journal of Advanced Science Computing and Engineering, vol. 4, no. 3, pp. 203-209, 2022.

[3] G. Pan, G. Qi, W. Zhang, S. Li, Z. Wu, and L. T. Yang, "Trace analysis and mining for smart cities: issues, methods, and applications," IEEE Communications Magazine, vol. 51, no. 6, pp. 120-126, 2013.

[4] J. Boga, T. Sunitha, and K. Manjula, "Technology based on the Internet of Things to Monitor Animals."

[5] D. Dutta, D. Natta, S. Mandal, and N. Ghosh, "MOOnitor: An IoT based multi-sensory intelligent device for cattle activity monitoring," Sensors and actuators A: Physical, vol. 333, p. 113271, 2022.

[6] M. A. K. Raiaan, N. M. Fahad, S. Chowdhury, D. Sutradhar, S. S. Mihad, and M. M. Islam, "IoT-based object-detection system to safeguard endangered animals and bolster agricultural farm security," Future Internet, vol. 15, no. 12, p. 372, 2023.

[7] B. Risteska Stojkoska, D. Capeska-Bogatinoska, G. Scheepers, and R. Malekian, "Real-time internet of things architecture for wireless livestock tracking," Telfor Journal, 2018.

[8] F. N. Yaşar, R. Barabanshchikova, İ. Taş, and N. N. Yoğurucu, "An IoT Based Feed System for Stray Animals," ed: IEEE, 2021.

[9] A. Easwaran, P. Arvindan, E. Dhanyasree, R. Surya, and S. Selvakumar, "Internet of things enabled smart animal farm prototype," in Journal of Physics: Conference Series, 2021, vol. 2070, no. 1: IOP Publishing, p. 012115.

[10] T. Vigneswari, "Smart IoT cloud based livestock monitoring system: A survey," Turkish Journal of Computer and Mathematics Education (TURCOMAT), vol. 12, no. 10, pp. 3308-3315, 2021.