

# Balancing Excitement and Environmental Conservation in Information Dissemination for Safari Game Drives

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**Abstract.** In the context of Kenyan Safari Game Drives, which traditionally rely on visual scouting and intermittent communication, challenges arise regarding the effectiveness of animal detection and environmental conservation. Consequently, animals experience stress, and tourists encounter difficulties in observation due to obstruction by other visitors. Addressing these challenges involves maintaining animal welfare while enhancing tourist satisfaction. To revitalize post-pandemic tourism and enrich safari experiences, this study proposes a wildlife spotting and sharing system. The proposed method integrates wildlife detection and sharing technologies guided by three core principles: preserving encounter serendipity, regulating information access, and promoting environmental conservation. The system architecture incorporates sensors, GPS, and tablet terminals to facilitate real-time data collection, animal identification, and information dissemination. This approach aims to foster an engaging, efficient, and environmentally conscious wildlife spotting and sharing experience, potentially establishing a model for sustainable wildlife tourism in comparable wildlife-rich regions.

**Keywords:** Wildlife Spotting · Game drive · Navigation System · Animal protection · Entertainment

## 1 Introduction

Kenya's wildlife tourism sector heavily depends on game drives as a central attraction, offering visitors a unique chance to engage with the natural environment and witness a diverse range of wildlife. Game drives, symbolic of Kenyan tourism, occur in natural wildlife habitats like nature reserves and wildlife sanctuaries. During these excursions, tourists embark on specially-designed vehicles to observe wildlife in their natural habitat, accompanied by experienced guides who explain the behaviors and habits of the animals. These expeditions, often lasting several hours or days, offer visitors the chance to witness a spectacular variety of wildlife, including lions, elephants, zebras, giraffes, and others, while appreciating the natural beauty and biodiversity of the ecosystem. The appeal

of game drives in safari is often enhanced by unexpected wildlife encounters, which typically rely on visual scouting by guides and the occasional exchange of sightings information between tourism vehicles.

The global tourism industry, including Kenya, has experienced a notable decline in the wake of the COVID-19 pandemic. As part of the efforts to rejuvenate Kenya’s tourism sector, the revitalization of game drives has emerged as a pivotal strategy. However, the existing manual practices of animal spotting and information exchange during game drives are plagued by inefficiencies. Instances arise where tourists spend extended periods on drives with few wildlife sightings. On the other hands, the clustering of multiple vehicles around sighted animals may cause stress to the wildlife, highlighting the necessity for a more structured information-sharing mechanism that prioritizes animal welfare.

As Ranaweera et al. [8] argue, the presence of tourists during elephant-watching activities in protected areas of Sri Lanka significantly increases the frequency and duration of alertness, fear, stress, and aggressive behaviors among different age and sex groups of elephants. Additionally, Kays et al.[5] mention the potential for tourist behavior to decrease the population of wild animals and disrupt the activity patterns of these animals. Balancing the improvement of animal sighting detection and sharing, while preserving the thrill of unexpected wildlife encounters, poses a complex challenge to be solved.

The objective of this study is to conceptualize, construct, and assess a wildlife spotting and sharing system tailored for Kenyan game drives. This system, named SafariCast, aims to investigate its effectiveness within safari game drives. Moreover, the study seeks to examine how SafariCast could integrate the improvement of animal detection and information dissemination among tourists while maintaining the integrity of the genuine safari experience characterized by unexpected wildlife encounters. In the context of the post-pandemic landscape, characterized by the imperative of revitalizing tourism as a cornerstone of Kenya’s economic recovery, this study assumes a distinct and pivotal role. The forthcoming insights have the potential to outline a framework for integrating technology into wildlife conservation endeavors, tourist engagement strategies, and the sustainable management of game drives. Such a framework could establish a precedent not only for Kenya but also for other nations abundant in wildlife, offering a sustainable approach to enhancing wildlife tourism experiences.

In summary, our key contributions are the following.

- We identified inefficiencies in current wildlife spotting and information sharing practices during game drives in Kenya, such as prolonged periods with few wildlife sightings and stress caused to animals by clustering vehicles.
- We introduced SafariCast, a system designed to enhance wildlife spotting and sharing experiences during Kenyan game drives. SafariCast aims to improve effectiveness, efficiency, and tourist engagement while maintaining the authenticity of the safari experience.

- We developed SafariCast as a solution, addressing discussions on sustainable tourism and wildlife conservation by balancing economic benefits with environmental and wildlife welfare considerations.

## 2 Related Works

The intersection of animal detection and location-sharing systems presents an innovative interdisciplinary approach to enriching wildlife spotting experiences during game drives. Exploring relevant research in these fields sheds light on the progression of methodologies and technologies, laying a sturdy groundwork for the proposed study. For instance, Kim et al.[6] argue that monitoring and predicting tourists’ spatial movement patterns from mobile phone data hold promise in contributing to biodiversity management in protected areas. Additionally, Barros et al.[1] forecasted peak visitation periods by tourists using geotag data and validated the potential utility of visitors’ time patterns as surrogate indicators for visitation rates.

### 2.1 Animal Detection

Park et al.[7] explore a cloud-based system used in a Smart Farm environment for real-time animal monitoring and detection. This system is designed to oversee the health and behavior of animals, providing alerts in case of abnormalities, ultimately ensuring the welfare of livestock. Karlsson et al.[4] focus on the tracking and identification of animals within a digital zoo context. The study is geared towards monitoring the location and behavior of animals, with a digital platform developed to disseminate information to visitors, thereby enriching their zoo experience.

### 2.2 Wildlife Communication Systems

The ZebraNet project[3], as explored by Jones et al., investigates energy-efficient computing techniques for wildlife tracking. This research outlines the design tradeoffs entailed in developing a system that optimizes energy efficiency while effectively tracking wildlife, offering early experiences and lessons from the ZebraNet deployment. Nisrine et al.[2] delve into a smart system for the collection and sharing of real-time vehicular mobility traces. Although the context differs, the methodologies and technologies explored could be relevant to devising an information-sharing system between vehicles during safari drives, ensuring efficient communication about wildlife sightings while minimizing environmental impact.

These studies collectively constitute a mosaic of methodologies, technologies, and experiences that could inform the design, development, and evaluation of SafariCast in the distinctive setting of Kenyan Game Drives. The gleaned insights from these studies could potentially steer the harmonization of animal detection enhancements with the preservation of authentic safari experiences, aiming towards a sustainable and engaging wildlife spotting and sharing endeavor.

### 3 SafariCast

Our proposed system, SafariCast, aims to reconcile environmental conservation with tourist satisfaction. This approach has centered around three core elements: maintaining the serendipity of encounters, restricting crowding, and equalizing opportunities for encounters.

#### 3.1 Requirements

Encountering wildlife during a game drive is inherently thrilling. Our approach aims to implement a structured information-sharing system while maintaining this excitement and considering stress on the animals.

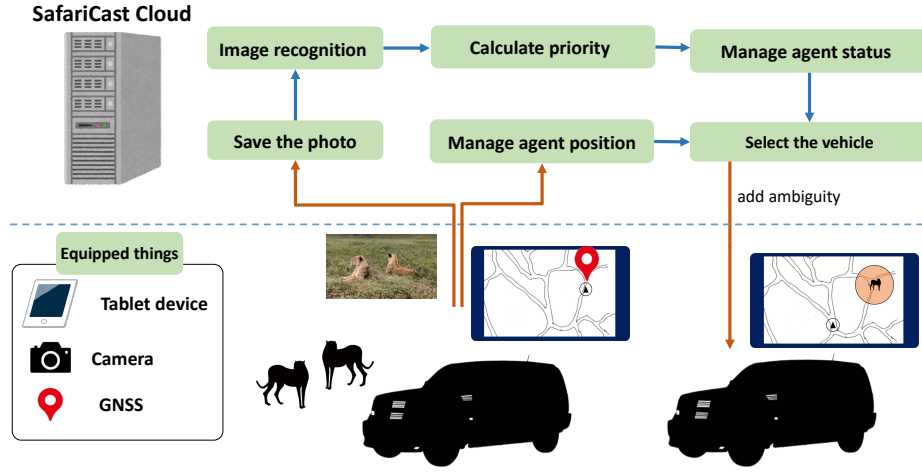
**Equalizing Opportunities for Encounters** Currently, one-to-one information sharing among local guides is the primary means of communication during game drives, which is not an efficient method of information sharing. Our proposed approach seeks to collect, distribute, and maximize participant satisfaction with location information of animals from all participants.

**Maintaining the Serendipity of Encounters** Providing excessive information to tourists may diminish the element of surprise and could potentially impact the habitat of animals. We will establish a system that limits tourist access to information. The priority of shared location information is determined by the encounter history of vehicles with animals and the distance from the animals. Additionally, shared location information will be displayed as an ambiguous circle rather than pinpointed locations. This preserves the excitement of finding animals, makes animals easier to find, and prevents vehicles from clustering around animals. Furthermore, by limiting information disclosure, we maintain situations where vehicles are less likely to become overcrowded.

**Restricting Crowding** Due to the tendency for vehicles to cluster around spectacular events such as sightings of the Big Five (elephant, buffalo, lion, leopard, and rhinoceros) or crossings of the Mara River, mechanisms will be introduced to regulate vehicle approaches when the threshold number of vehicles is near target animals or areas. This prioritizes animal welfare and minimizes impacts on habitats.

#### 3.2 Implementation

To facilitate information sharing on SafariCast, it is necessary to have equipment for capturing animals and software for processing information. Below, we enumerate the equipment to be installed on each vehicle and the software used for exchanging information. The system architecture is shown in Figure 1.



**Fig. 1.** The system architecture of SafariCast consists of both hardware and software components, with data being processed on the SafariCast Cloud.

**Hardware Components** Each vehicle is equipped with a tablet device that displays the safari map, current location, vegetation, and the probability range of animal presence based on previous encounters. Sensors utilized by the device include:

- GPS: To acquire precise location data of vehicles and potential sighted animals.
- Camera: To capture images.

We presume that internet connectivity is available within the safari area. In fact, we have already verified that the mobile network (LTE network) covers a broad expanse of the safari.

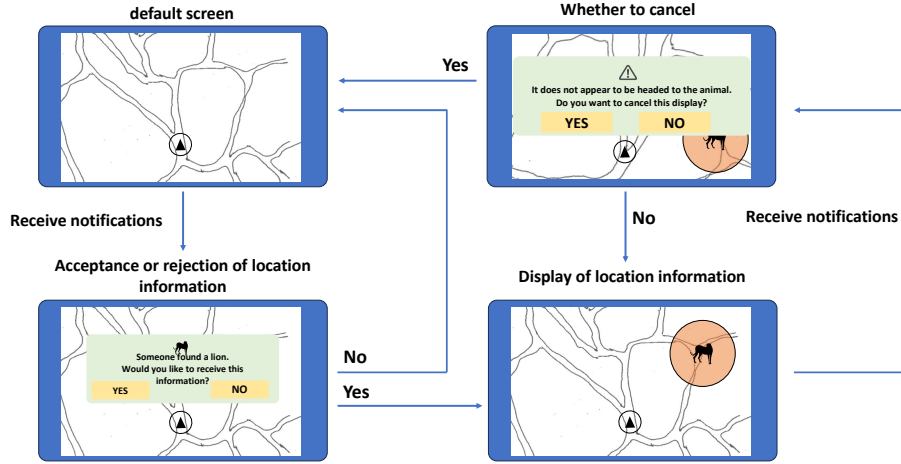
### Software Components

- Image Analysis: To identify animals from captured photos by deep learning models.
- Navigation Map: Provides users with real-time visual surroundings.
- Wildlife Location Acquisition Function: Obtains and displays precise wildlife coordinates nearby.

### 3.3 Information Sharing Procedure of SafariCast

The details of SafariCast’s information-sharing procedure are explained here. The flow of information sharing in SafariCast is depicted in Figure 2, where SafariCast calculates priorities based on the number and rarity of encountered

animals and determines whether to share information accordingly. Once shared, the animal's location is displayed on the tablet screen, allowing participants to make informed decisions.

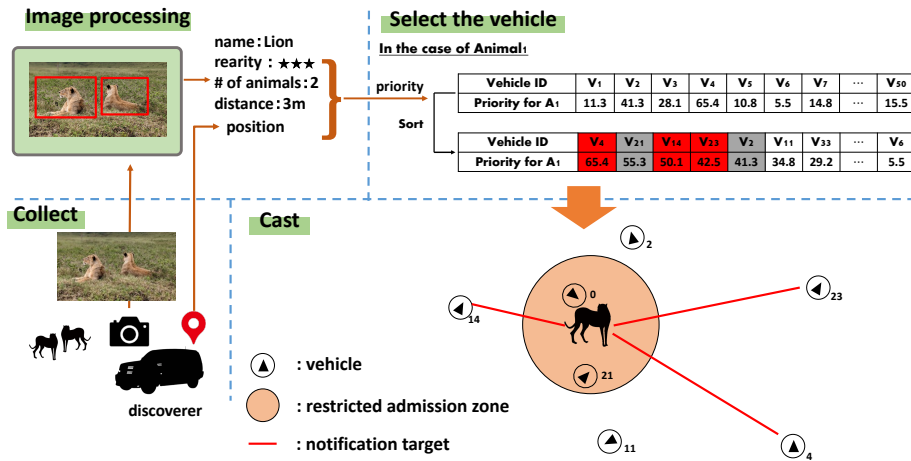


**Fig. 2.** This represents the flow of information that is notified to tourist vehicles. Tourists can choose whether to receive information about animals. Also, if tourists are clearly not heading towards their destination, they can turn off the display.

**Animal Discovery** Animal discovery is conducted through cameras installed in vehicles. The camera is not continuously recording but is assumed to start recording when the vehicle stops. Upon animal discovery, a few frames of recorded video are uploaded to SafariCast. From these uploaded images, the species, total count, and estimated distance to the animal are inferred. Based on the information obtained from the images, SafariCast updates the encounter history of the discovering vehicle. It also evaluates the impact of the images on other individuals and shares the information. In the example of Figure 2 and Table 1, Vehicle 0 has discovered animals.

**Conditions for Receiving Notifications** In SafariCast, information is shared among vehicles based on their priority rankings. When delivering information, the priority of all vehicles is compared, and information is distributed in descending order of priority values. From the perspective of wildlife conservation, an entry restriction of up to 5 vehicles within a 1km radius of the animal is implemented. In the example depicted in Figure 3, since there are already 2 vehicles within a 1km radius of the animal, the next 3 vehicles will receive the information.

**Delivery Restrictions** When the total number of vehicles receiving animal location information and the total number of vehicles within a 1km radius of the target animals (restricted entry zone in Figure 3) reach the capacity (5 vehicles), notification delivery stops. Once the capacity limit is below, notification delivery resumes. When counting the capacity limit, the vehicle that first discovered the animals is also included. If a rarer animal is found within a 1km radius of animals already discovered, notifications are updated to inform about the rarer one. If there are no updates in observation information within the same zone, notification delivery stops 15 minutes later.



**Fig. 3.** This diagram illustrates the flow of information sharing related to animal A1. The location information of animal A1 is disseminated to vehicles with high priority values. However, vehicles that have already encountered the same animal as A1 or vehicles within the restricted area do not receive information sharing.

**Notifications** Figure 2 illustrates the screen transitions of the tablet devices in each vehicle. Each vehicle's tablet device receives a notification: "Lion sighting. Do you want to acquire this information?" This notification can be declined. If declined, it is forwarded to the next participant. Once received, the vehicle cannot freely cancel the notification until it enters the zone of the target animals. If the receiving vehicle is evidently not heading towards the zone of the target animals, a message is sent to the participant: "It seems you are not heading towards the target animals. Do you want to cancel?" The user is notified and can choose whether to cancel or not. If the search is interrupted in this manner, no cooldown period is imposed.

### 3.4 Process of SafariCast

In the previous version of SafariCast, satisfaction was used as a metric.[9] However, incorporating the subjective notion of satisfaction led to ambiguity. Therefore, this paper introduces a new metric called priority. Priority is the criterion used to determine which vehicle to share information with when an animal is discovered. It is calculated based on the vehicle's encounter history with animals, the rarity of the animal, and the distance to the animal.

#### Priority Calculation Formula

$$P = \frac{(S_a \times S_v)}{(L_a - L_v)^2}$$

where  $S_a$  is status of the animal,  $S_v$  is status of the vehicle,  $L_a$  is location of the animal and  $L_v$  is location of the vehicle.

#### Procedure for Determining Delivery Targets

1. For each animal, calculate the priority for all vehicles and store it in the dictionary `animal.priority[vehicle]`.
2. Sort the dictionary in descending order of priority.
3. Remove vehicles close to the target animal and vehicles that have already encountered the target animal from the dictionary.
4. Cast information to the top vehicles in the dictionary. The number of vehicles that can receive information varies depending on the number of vehicles within the restricted area of the animal.
5. Each vehicle receives the information with the highest priority from the animal.

**Algorithm for Selecting Notification Targets** Algorithm 1 defines a function that computes priority values for vehicles based on various factors including the status of animals, the status of vehicles, and the distance between animals and vehicles. Algorithm 2 then generates a dictionary to hold these priorities, calculating them for each vehicle in relation to all animals. Additionally, it identifies vehicles that are adjacent to animals based on a specific threshold distance. Afterward, the priorities are sorted in descending order to facilitate subsequent processing. In Algorithm 3, certain elements are removed from the dictionary, such as vehicles that have already been associated with an animal and vehicles that are too close to an animal. Finally, Algorithm 4 ensures that each vehicle is assigned the position information of the animal with the highest priority, setting this information as the vehicle's `vehicle.goalposition`.



**Algorithm 1** Algorithm for calculating priority

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1: procedure CALC_PRIORITY( $L_a, L_v, S_a, S_v$ )
2:   Input:
3:      $L_a$ : animal's Location
4:      $L_v$ : vehicle's Location
5:      $S_a$ : animal's state
6:      $S_v$ : vehicle's state
7:   Output:
8:      $P_{av}$ : priority
9:      $r^2 = (L_a.x - L_v.x)^2 + (L_a.y - L_v.y)^2$ 
10:     $P_{av} = \frac{S_a \times S_v}{r^2}$ 
11:    return  $P_{av}$ 
12: end procedure

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**Algorithm 2** Priority Calculation and Sorting

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1: for each animal in all_animals do
2:   for each vehicle in all_vehicles do
3:     calculate priority for animal with vehicle:  $animal.priority[vehicle] \leftarrow$ 
       calc_priority(animal, vehicle)
4:     if ( $animal.location - vehicle.location$ ) < restricted_distance then
5:        $animal.neighbors \leftarrow vehicle$ 
6:     end if
7:   end for
8:   Sort  $animal.priority$  in descending order
9: end for

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**Algorithm 3** Selecting

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1: for each animal in all_animals do
2:    $tmp\_dict \leftarrow animal.priority$ 
3:   for each vehicle in all_vehicles do
4:     if ( $vehicle \in animal.neighbors$ ) or ( $animal \in vehicle.encounted\_list$ )
       then
5:        $tmp\_dict.pop(vehicle)$ 
6:     end if
7:      $animal.cast\_member \leftarrow tmp\_dict[: \text{restricted\_number} -$ 
       (length of  $animal.neighbors$ )]
8:   end for
9: end for

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**Algorithm 4** Receiving

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1: for each animal in all_animals do
2:   for each vehicle in animal.cast_member do
3:     vehicle.candidate  $\leftarrow$  animal
4:   end for
5:   for each vehicle in all_vehicles do
6:     for each animal in vehicle.candidate do
7:       max_priority  $\leftarrow$  0
8:       if max_priority < animal.priority[vehicle] then
9:         max_animal  $\leftarrow$  animal
10:        max_priority  $\leftarrow$  animal.priority[vehicle]
11:       end if
12:     end for
13:     if max_priority  $\neq$  0 then
14:       vehicle.goal_location  $\leftarrow$  animal.location
15:     end if
16:   end for
17: end for

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**Algorithm 5** Spotting

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1: for each vehicle in all_vehicles do
2:   if (animal.goal_location - vehicle.location) < spotting_distance then
3:     vehicle.encountered_list  $\leftarrow$  animal
4:   end if
5: end for

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## 4 Simulation

To validate the efficacy of SafariCast, an experiment is conducted. In this context, a simulation is employed to assess the impact before installing equipment on actual vehicles.

### 4.1 Condition

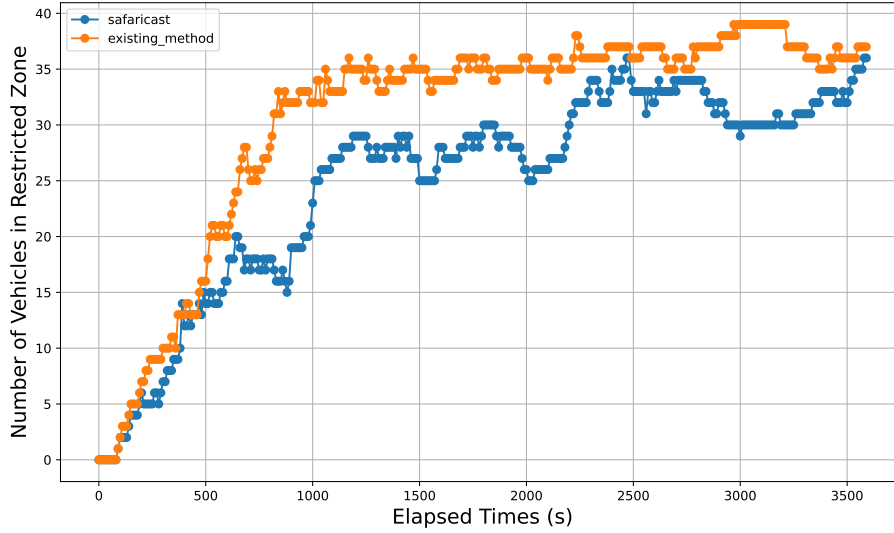
We conducted simulations assuming 50 tourist vehicles would engage in a 60-minute game drive in a  $10\text{km} \times 10\text{km}$  safari area. When controlled by SafariCast, we delimited a range of 1km from the animal sighting position as the restricted area. We set the total number of vehicles within the restricted area and the number of vehicles receiving information to be 5. Additionally, the prioritization of receiving information by vehicles was determined by their priority values. Conversely, when not controlled by SafariCast, there were no restrictions on the number of people in the restricted area, and casting was done in order of proximity. We conducted simulations for each case described above. By comparing the fluctuations in the number of vehicles in the restricted area during the simulations, we evaluated the effectiveness of SafariCast.

### 4.2 Result

Figure 4 shows the numbers of vehicles within the restricted areas with and without SafariCast. From the figure, the introduction of SafariCast reduced the number of vehicles within the restricted area. Compared to the without control, SafariCast proved to be an effective way to control how vehicles move in animal habitat areas.

## 5 Discussion

The simulation result, as depicted in Figure 4, confirms that SafariCast reduces the number of vehicles near animals, thereby potentially alleviating stress on the animals. Moreover, this study indicates the potential contribution of SafariCast not only to animal conservation but also to enhancing the quality of tourism experiences. The decrease in vehicle density within the restricted area is expected to enrich the opportunity of wildlife observation and natural experiences. However, in real game drives, animal positions are sometimes identified through visual scouting and communication among guides. These elements were not considered in the simulation, and their impact remains unclear. Furthermore, the outcome may vary depending on the extent to which the rarity of animals and encounter history are prioritized. Future research should explore the optimization of these parameters. Additionally, in this simulation, vehicles are set to move linearly toward the location of the animals. However, in actual game drives, there are geographical constraints such as roads and rivers, which should be considered. Conducting simulations under conditions closer to real-world settings, accounting for these constraints, is desirable.



**Fig. 4.** Simulation result with and without SafariCast. This indicates the number of vehicles within the restricted area over time. The orange line represents the scenario without control, while the blue line represents the scenario with the proposed method. It is evident that employing the proposed method results in fewer vehicles within the restricted area.

## 6 Conclusion

SafariCast embodies an approach aimed at revitalizing the wildlife spotting and sharing experience on Kenyan safari drives. By intertwining real-time detection and information sharing technologies, it seeks to overcome the inefficiencies of traditional spotting methods while preserving the thrilling unpredictability of wildlife encounters. Based on the simulation results, we confirmed that controlling information with SafariCast can alleviate vehicle congestion near animals. However, in this simulation, we could not verify the equalization of tourist encounters with animals. In the next study, we aim to evaluate the effectiveness of simulations in animal encounter opportunities and flexibly address these elements in a trade-off relationship. Furthermore, following the evaluation of SafariCast through simulation, our aim is to pursue its practical application. In the future, we are considering extending the application beyond Kenya to other regions abundant in wildlife, thereby broadening the horizons for sustainable wildlife tourism.

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