A Sensor Based Anti-Poaching System in Tanzania National Parks

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Abstract- In recent years poaching incidents has been massively increased encompass slaughtering of endangered species in Tanzania and Africa in totality. Different initiatives has been taken world widely including establishment of International Anti-Poaching foundation (IAPF). Tanzania in particular has taken several initiatives on the matter at different time including sending her own military army across the borders of National parks as an attempt to eradicate poaching activities. However poachers are still continue to put a bullet on the heads of these species of monumental importance. The main idea presented in this paper involve employing a modern and a sophisticated technology in which poachers will be left behind and being netted easily there by eliminating Poaching activities. The idea utilize animals themselves with sensors as mobile biological sensors (MBS) mounted with sensor fusion (having visual, infrared camera and GPS) that transmits the location of MBS, access points for wireless communication and a central computer system which classifies animal actions.

The system propose three different action of responses, firstly: access points continuously receive data about animals' location using GPS at certain time intervals and the gathered data is then classified and checked to see if there is a sudden movement (panic) of the animal groups: this action is called animal behavior classification (ABC). The second action can be called visualization where by different image processing techniques of the obtained images surrounding an animal group are performed and therefore provide an ample assistance in understanding what makes sudden movement of the animal group. The last action is to send messages to the game ranger's cellular phones about the panic of animals and the location through GSM network

Index Terms- Biological sensor, Computer vision, mobile sensor, Access point, sensor fusion

I. INTRODUCTION

Poaching is the illegal taking of wildlife, in violation of local, state, federal or international law. Activities that are considered poaching include killing an animal out of session without a license, with a prohibited weapon or in a prohibited manner such as jacklighting. Killing a protected species particularly Elephant as in this paper, exceeding one's bag limit or killing an animal while trespassing are also considered as poaching.[1]

The problem has rapidly increased from 1990s to date particularly on elephants for example in 2011 the total world population of elephants was 423,000 down from 1.3million in 1979.In 1994 Tanzania had a population of 355,000 but this number dropped promptly to 180,000 in 1999 and less than that number in 2011. According to data from the Tanzania Wildlife Research Institute, Tanzania is losing 30 elephants daily to poaching. The situation on the ground tells that the remaining elephants are in danger of being completely wiped out if urgent measures are not taken. Poaching incidents are continuously taking place because of illegal trade of ivory marketed in Asia and United States. While China is blamed to control about 70 percent of ivory illegal trade, United States is the next largest consumer.

Chinese uses ivory for making arts and utilities. Americans use ivory to make gun and knife handles and as decorative details on these weapons. [2]

(a)

(b)

(c)

(d)

(a)An elephant hit by spear on his head
(b) sophisticated weapons used by poachers
(c) Ivory packed in different size
(d) Baby elephant lies on the ground after her mother was shot dead by poachers immediately after she was born. [2]

It is clearly mentioned that the demand of ivory is increasing for different reasons however the animal species particularly elephants are at danger of being lost in the world. Biologists say the loss of elephants would have a significant negative effect on forests and savannahs. [1, 2]

To get rid of poaching activities that endanger ecological imbalance a sophisticated technology need to be applied in collaboration with the current anti-poaching efforts.

This paper presents a new system for anti-poaching involving sensor fusion (i.e. visual and infrared cameras, GPS) and computer vision techniques for real time visualization and observation of a significant animal movement. With this system a properly selected sensor fusion (with visual and infra-red camera and a GPS) is attached to the body of a targeted species, if for any reason animal panic or sudden movement of animals is observed three actions will take place. The first action is a sensor will send a location of MBS to the central computer system, the second action is through wireless access point a text message will be sent to game reserve officers alerting them about panic of animal and the third action is the image will also be sent to the central computer system to be processed and hence help to identify what makes animal panic.

II. RELATED WORK

This research suggest the use of animal attached with certain type of sensor and form a Mobile biological sensor (MBS). Therefore both the use of sensor with animals and the existing anti-poaching systems have to be investigated. Many scientific studies has put more efforts on forest fire detection through the study of animal behavior.

Animal behavior research using sensors has been carried out for some time. A great deal of scientific research has been conducted with regard to the existence and habitat of the marine and land animals. One such study has collected data about oceans. ”UC Santa Cruz researchers are using marine animals outfitted with sensors to collect oceanographic data. For example, sensors on California sea lions collect the animals' location, speed, and dive data along with ocean temperature and salinity information. The data is then transmitted to the researchers via satellite” [3]. In another study, the first effective method was based on a pyro-detector which sensed the temperature contrast between the animal’s body and the surrounding pasture [4]. There are similar studies related to animal tracking using sensors. The main idea is therefore to show the existence of many investigations into animal tracking using sensors.

Nevertheless few research works are directly subjected to Anti-Poaching. In a research conducted by Department of Sensor Science Technology, Council for Scientific and Industrial Research (CSIR) in collaboration with Centre for Wildlife Management, University of Pretoria, South Africa by Margarita Mulero-Pa´zma´ny, Roel Stolper and D. van Essen proposed the use of Remotely Piloted Aircraft System (RPAS) as a Rhinoceros Anti-Poaching Tool in Africa.[5]

Remotely Piloted Aircraft Systems (RPAS), sometimes also referred as Unmanned Aerial Vehicles (UAVs), Unmanned Aerial Systems (UASs) or drones (the ones for military purposes), are aircrafts (fixed or rotary wings) that are equipped with cameras and or other sensors and can be sent (using manual, semiautomatic or automatic control) to a destination to gather information. These aircrafts act like an ‘‘eye in the sky’’ with the operator at the ground control station receiving data or sending orders to the aerial platform. [6]

RPAS have been used for locating ‘‘enemies’’ in military applications for the last 20 years [7], and more recently they have started to play a role in many civilian tasks, including wildlife monitoring. Their research describe the use of a small low cost RPAS equipped with three different types of cameras to test their ability to support rhinoceros anti-poaching tasks in cooperation with a specialized security company working in the KwaZulu-Natal province of South Africa. They performed several flights in order to test the technical capabilities of the system to detect rhinoceros, to reveal simulated poachers and to do fence

surveillance. They evaluated the effectiveness of the system at different altitudes and times of the day and night, and over the two main habitat types in the area: open grassland and forest. Considering the most common modus operandi of poachers, they analyzed the aspects that affect remotely piloted aircraft's integration in anti-poaching operations. [6, 7]

However for African countries which are mostly poor and developing countries like Tanzania employing such a system may alleviate the overall cost and economic burden on governments, for example the price for a single RPAS equipment bought from Spain was 13,750 €. Also as a reference, the system they used has performed more than 500 flights with an approximate total investment of 14,000 €. [6] This is the huge amount of money for a country like Tanzania to invest in only one sector while it is equivalent to annual budget amount of a sensitive ministry and therefore it is not cost effective for Tanzania to employ it despite the fact that RPAS has contributed a valuable and respectful thoughts in the field.

Another important research has been conducted in Kenya with the aid of World Wild life Fund (WWF). The study involve deployment of specialized rhino horn tracking systems combined with forensic DNA technology which will allow for 100 percent traceability of every rhino horn and live animal within Kenya. The presented tracking system involves implanting microchips into the horn of every rhinoceros in Kenya in a bid to keep the dwindling population safe from the ever-increasing presence of poachers. The microchips in the horns of rhinos may deter poachers from trying to smuggle the contraband out of Kenya. When a rhino is killed and the horn is hacked off and taken away, if this horn is confiscated and the microchip tag can be identified, it can be tracked back to a poached animal and it can actually show and prove that this was a poaching incident. [8].

However, the approach presented in this paper is to prevent poaching incident before it happen and or while it is happening which is worth enough than waiting a problem to happen and capture the poachers after they have already made poaching incident. Using animals as sensor for incident detection is not a new idea but it has been limited to a few of incident types and mostly is disaster such as earthquake. For example Yeung describes an example of observing animals' behavior for early earthquake alert, but the author gives no guaranty that his study works correctly for every earthquake [9]. Kahn suggested an idea that the best and the cheapest biosensors are already distributed globally but generally ignored: They're called animals [10]. Kahn's idea leads the scientists to start new investigations to be made on animals. Also another research study has been conducted by Lee et al. [11].

In their study, they offered a Bio-adhoc sensors network for early forest fire warning system for mountain areas, and they used animals as wireless adhoc nodes.

However, the proposal presented in this paper is based on the usage of many access points explicitly constructed in the National parks instead of an adhoc network structure. Although it may not seem to be feasible to install sufficient number of access points to cover whole Parks in Tanzania, some critical points which are highly under the risk of poaching incidents, can be selected for the access point locations. Moreover, the usage of the access points would remove the risk of interruption of communication (network failure) that usually occurs in adhoc networks, if animals are used as wireless nodes only.

In addition to that is another important research which is similar to the study presented in this paper conducted by Yasar Guneri Sahin [12]. In his research he presented the use of animal as a biological sensor to track animals for fire detection system. Furthermore in his study Yasar Guneri Sahin has focused on animal behavior classification and thermal detection. This paper however focus on not only animal behavior but also what makes an animal to behave in a certain way in response to current event.

III. MOTIVATION

Collectively the previously stated methods and others which are similar in regard to animals tracking and early may be successful in their own right, but, applying these into a single homogenous system would have significant return. While scientists are tracking animals to gather information on their daily habits, such as hunting or mating, forest rangers can use the gathered data for poaching prevention.

In addition, this paper offers a solution to problems stemming from using static sensors and Satellites in detecting animal behavior or Poaching prevention. Using satellites focused only on a National parks causes many extra costs and, of course it requires a satellite to exist. Also using drones for poaching prevention has resulted many problems including mistakenly attack and issues of human right breaching. With sensors attached to fixed coordinates, restricts the effective detection areas and this situation therefore, requires too much sensors to be set up for a hectare of a park. In the same way, using fixed cameras with image processing techniques for detection requires multiple cameras per hectare and, these use limited to areas with full light, so it may be useless for shadowed areas, densely forests, and cliffs.[13,14,15]

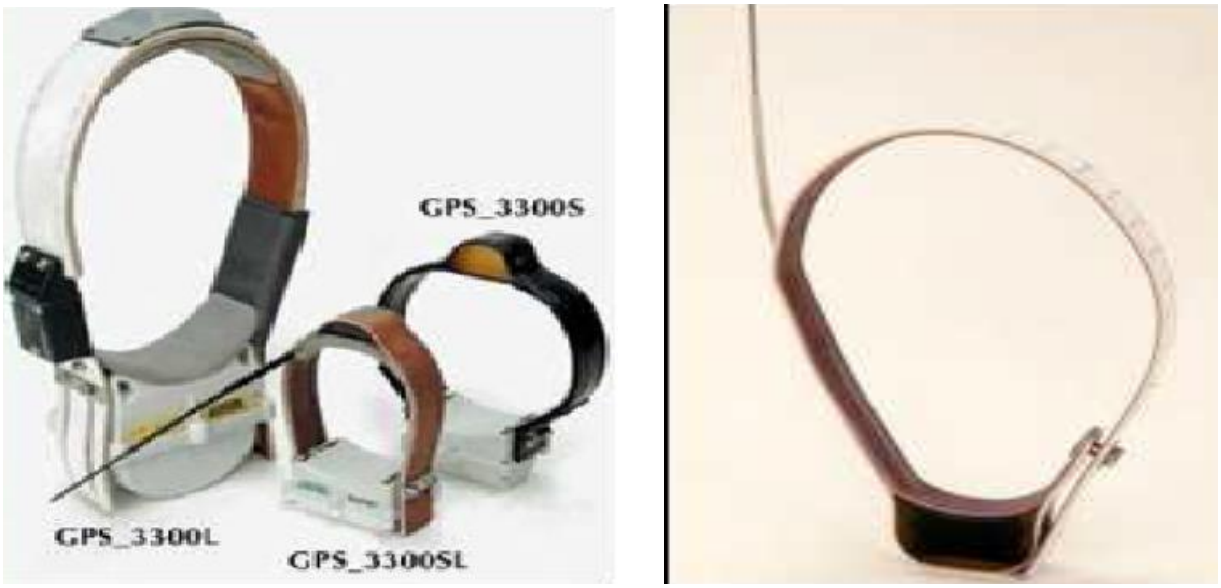
Using animals as MBS resolves the problems related to fixed sensors. The proposed system, additionally, has a classifier which built-in measures to use animal action (panic) to signal Poaching incident, show the location though GPS and some images of the incident. Furthermore, this system may assist monitoring normal animals' death, and understanding animals' group behavior.

Animals as a Mobile Biological sensors

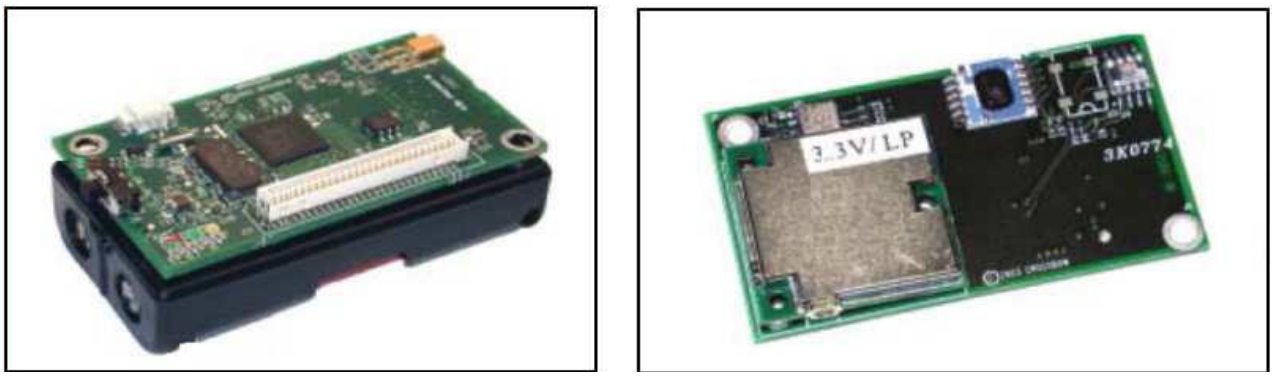
This research paper proposes the use of animals as a mobile biological sensor (MBS). An appropriate animal is chosen in this case elephants and attached with an appropriate sensor. The preferred part of the body of an elephant is attached with a sensor fused with visual and IR camera. The part of the body must be carefully chosen such that it will not disturb an animal and give wrong result because of unnecessary movements resulting from scaring an attached object. Also the position of the sensor must be in such a way that cameras attached on it will also be able to send information to the central computer system. The most important issue in the selection of sensor is that they must all have GPS features for location detection.

Figure 1 below show example of the chosen species i.e. elephant that can be used as MBS

Figure 2: Some elephants attached with sensors that can be used as MBS.



(a)



(b)

Figure 3 Sample sensors that can be used in the system

Figure 3 (a) shows the collar type sensors that are usually used for mammal and large terrestrial animals. Whereas 3(b) shows peripheral devices used in collar sensors and the sensor boxes.

These sample sensors have different operational specifications such as battery life, weight, burst rate etc. as shown in Table 1. There are, in fact, many other sensors that can be used in the system with long life batteries and different features. If battery life of the selected sensors is short, the batteries must, therefore, be recharged periodically. [12]

Model	Sensor type	Physical specifications			Estimated life (days)	
		Size in mm (dia x length)	Air Weight g.	Water weight g.	2s between bursts	5s between bursts
Sensors for use with SRX 400A / SRX 600 radio receiver family:						
SR-M11-12	Motion	11 x 41	7.7	4.3	59	137
SR-PM11-25	Pressure & motion	11 x 58	11	5.2	203	497
SR-PM16-25	Pressure & motion	16 x 53	18	12	487	3 yr.

Table 1: Sample sensor specifications for the system

IV. THE PROPOSED SYSTEM INFRASTRUCTURE

The proposed system infrastructure can be adapted from existing Animal tracking systems or install the new one. The constituents of the system can vary but the compulsory devices essential to the system includes the following:

***Communication channel*:** The best method proposed in this paper is the use of access points as this method is cost effective. Access points are used to collect movement data from sensors attached to elephants (MBS) and send them to Central computer. To succeed this a GSM base stations such as those of telecommunications companies like TIGO, VODACOM and AIRTEL can be used. Also high voltage poles, tall massive trees and watchtowers are possible access points. However satellite based systems can also be applied, employing satellite system is fairly complex and costly as it requires a satellite to focus on specific area only such as national parks only.

***A central Computer system**:* This device must be trained with neural network, the device will classify data received continuously from MBS via access point and suggest if its normal movement or it's a movement caused by a dangerous action like poaching.

MBSs: which is important part of the system as stated earlier, the essential task of MBS is to abrupt change of pressure in an animal group (panic) due to sudden movement and also to send the current location of an animals to the access point in which access point will send it to central computer

***Cellular smartphone*:** This devices will receive a message about the panic of animals and the location where that panic is taking place. The author suggest that the device must be owned by game rangers at work who will be ready to take action whenever they receive a message, however the information received in the cellular phone must be synchronized with those from a central computer system for reliability.

Trustworthy, robust and highly sensitive sensors must be combined with suitable animals to enhance system reliability and sustainability. [12]

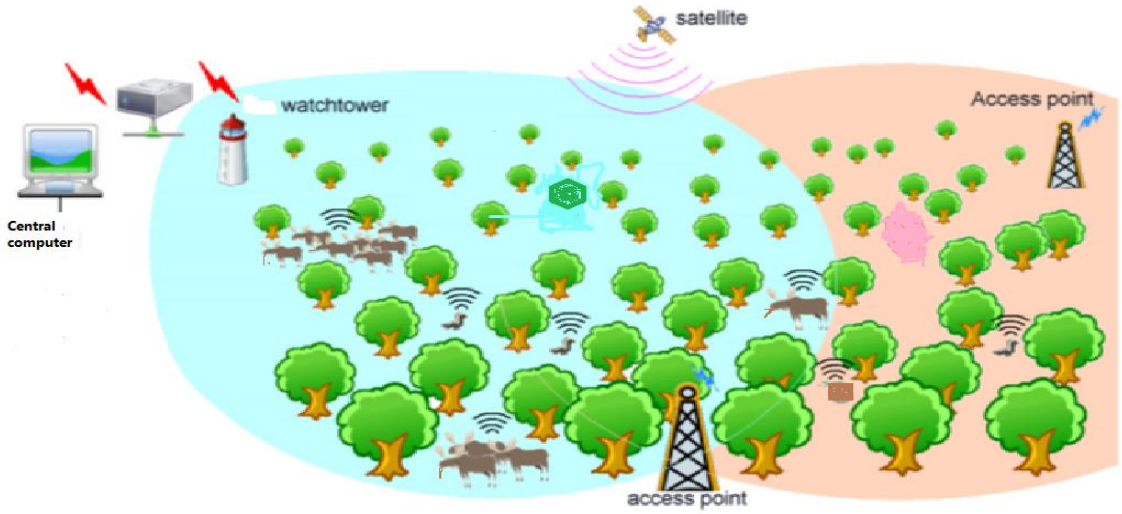


Figure 4: Poaching prevention system infrastructure

V. METHODOLOGY

The system works as follow: Access point receives MBS location continuously and sends it to central computer where it stores it in a database. This computer is fed with a specific algorithm of Artificial intelligent. A classifier indexed to the database will continuously check the database to determine any abnormalities on MBS's action. Using artificial intelligent tool a classifier will attempt to determine whether or not there is abnormalities on animal action compared to usual learned behavior. If a sudden panic of animals occurs an abrupt change in the graph of a classifier in the central computer occurs, this shows a potential incident and the system respond by first rises an alarm, secondly displaying the current location using GPS, thirdly the system will try to display what is taking place by processing received image with different techniques such as edge detection, thresholding and filtering to ensure that users are getting a clear image of what is happening. Furthermore a system will send a short message (SMS) to the game rangers through a GSM network to draw their attention on the suspected area. If immediate measures are taken by the game rangers poachers will be easily arrested and poaching will be eliminated in this way.

VI. DISCUSSION

The system proposed by this paper uses the animals as a Mobile biological sensor, In order to determine whether to apply this system in the particular parks such as Tanzania National parks, it may be crucial importance to look at some advantages and disadvantages of the system, Amongst advantages of the system are the system is very convenient and can be easily adopted to current anti-poaching systems, the system is cost effective as few sensors are needed and can be integrated to available infrastructure, Applying this system will reveal more knowledge on animal behavior, using mobile sensor provide a wide range of poachers detection than using fixed sensors, the system can be applied for other purpose such as comprehensive animal death.

As stated above the system may have some drawbacks such as: It is not easy to capture these dangerous animal like elephant and attach with sensors and hence need trained personnel. Also the use of battery bring about many problems such as pollution and extra radiation. Moreover each battery need to be changed periodically but capturing MBS for this purpose is not easy. Furthermore if a battery operate incorrectly wrong data would be sent.

VII. CONCLUSION AND FUTURE WORK

This research paper presents the use of animals as MBS, and therefore it can be applied to any species in danger at a particular time. However the system doesn't come to replace the current anti-poaching initiatives but rather to combine the effort in order to get rid of poaching instance. This system could prevent potentially serious Poaching activities occurring in different parts of Africa particularly Tanzania. It is the hope of author that if Tanzania National Parks (TANAPA) employ this sophisticated technology to the current worse situation of poaching activities will be of tremendous advantageous to TANAPA as it is reliable and will reduce the economic burden of investing too much on Anti-poaching. As the system has not yet actually implemented, some additional unforeseen disadvantages may occur.

However the advantages suggest that it could be implemented with tremendous success and ecological benefits.

To improve the system in future the author suggest that new wireless technology can be applied, Also the use of innovative computer vision technology will improve the system capability to detect poachers positions in real time. Lastly new sensors with improved capacity and robustness can be applied to the system.

Therefore it is noticed that the life of important animal species are threatened today due to poaching, and therefore if affirmative actions are not enforced, the loss of certain species which will lead to dramatic ecological imbalance will occur. This paper aims at presenting an alternative way to fight Poaching using sophisticated technology which seems to be effective and cost-effective to employ and use it.

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