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Camel Detection System over Optical Ground Wire among Highways between Cities and Villages

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Abstract- Gulf countries such as Saudi Arabia, Kuwait, Qatar, and the UAE face recurring hazards due to camels crossing highways, often leading to fatal car accidents. The current mitigation strategy—constructing double fences on both sides of highways—is both capital- and labour-intensive, especially considering the region's harsh climate and long highway stretches (e.g., the 380 km Riyadh–Dammam route). To address this issue more efficiently, this patent proposes an innovative, cost-effective monitoring system that leverages existing power transmission towers and infrastructure alongside highways. These power towers, connected via power lines and Optical Ground Wire (OPGW) fibres, are already used to transmit electricity between substations. The proposed system involves mounting a Local Access Network (LAN) on each tower, composed of an outdoor industrial switch and a long-range camera. Each switch is powered by a standalone DC system utilizing solar panels, Lithium Iron Phosphate batteries, and an Automatic Transfer Switch (ATS), ensuring operation under extreme environmental conditions. The long-range cameras, connected via PoE, continuously monitor the highway for camels. Captured video is analysed in real-time by a YOLO (You Only Look Once) object detection algorithm hosted in a centralized data centre. Once a camel is detected, an alert is automatically sent to the highway security team via SMS, with location data derived from the reporting camera's IP address. This solution eliminates the need for costly new infrastructure and extensive maintenance, offering a scalable, environmentally resilient system to prevent camel-related accidents across Gulf highways.

Keywords- Safety, OPGW, Camels, and YOLO

I. INTRODUCTION

Animal crossings on highways pose a significant risk to both motorists and wildlife, leading to thousands of accidents annually worldwide. Collisions involving large animals such as deer, moose, or camels often result in severe vehicle damage, injury, or even death. In the Gulf region—particularly in countries like Saudi Arabia, the UAE, Kuwait, and Qatar—camels are the most common hazard due to their size and the traditional practice of open-range herding. According to the World Health Organization (WHO), road traffic injuries are a leading cause of death in the Middle East, and animal-related collisions contribute significantly to this figure [1]. In Saudi Arabia alone, over 5,000 camel-related road accidents were reported between 2015 and 2020, resulting in hundreds of fatalities [2].

A study by the Transport Research Laboratory found that animal-vehicle collisions globally cause over 1.5 million accidents annually, with economic damages exceeding $8 billion [3]. In the UAE, animal-related crashes account for approximately 8% of all road accidents in rural areas [4]. Camels, due to their height and weight (up to 700 kg), pose a unique threat as they can crash through a vehicle's windshield upon impact, causing deadly consequences. Traditional measures such as fencing and warning signs have proven costly and often ineffective due to harsh environmental conditions and maintenance challenges.

To address this issue, intelligent real-time detection systems offer a promising alternative. The YOLO (You Only Look Once) algorithm is a deep learning-based object detection system known for its speed and accuracy in identifying objects in images and video frames. By integrating long-range cameras with YOLO-based image processing, animals like camels can be detected before they enter the roadway, allowing highway patrol teams to respond proactively. This approach minimizes accidents while reducing reliance on physical infrastructure.

II. DESIGN AND TOPOLOGY OF CAMEL DETECTION SYSTEM

Gulf Countries such as Saudi, Kuwait, Qatar and UAE are suffering from camels that cross the highways between cities, villages and towns as this may cause car accidents with camels. Gulf countries tried to resolve this by putting two fences beside the highway (right and left) as a protection to prevent any car accidents with camels by stopping camels crossing the highway. This is considered a very costly solution as it requires excavation and trenching the foundations of fences and then lying the fences on both sides of highways for hundreds of kilometers for instance 380km between Riyadh and Dammam city. In addition, it requires a lot of maintenance as Gulf Countries are suffering of sandstorms and tough weather that may destroy and damage the metal of fences. Therefore, maintaining the fences in a good condition is extremely expensive as it needs a high amount of manpower. Otherwise failing to maintain the fences will result in several camels that cross the highways which may cause many car accidents and deaths. Figure 1 depicts the current solution to separate between camel's area and the highways.

Figure 1: Current Solution to Separate Between Camel's Area and Highways

This paper shows depth explanations for an innovative idea that focuses on utilizing the exiting power towers beside the highways where these power towers are utilized to transmit the electricity between power sub-stations to feed the cities, villages and towns as depicted in Figure 2.

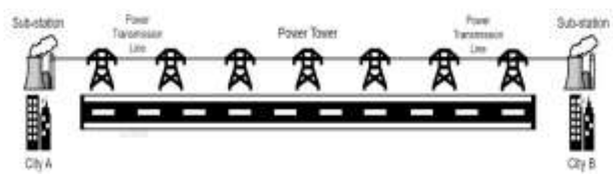

Figure 2: Power Lines between Power Sub-stations

There are several power towers scattered among the highway, and they are connected to each other through power transmission lines. These scattered power transmission lines and power towers are utilized mainly to transmit the electricity between cities, villages and towns by connecting several sub-stations together. In order to remotely control and manage the power devices by Electricity Infrastructure Operations Center, there are exiting fibers that are lied over or under the power transmission lines between the sub-stations and power towers. This fiber is called Optical Ground Wire (OPGW). Figure 3 presents how both OPGW and Power Transmission Lines are lying between power towers.

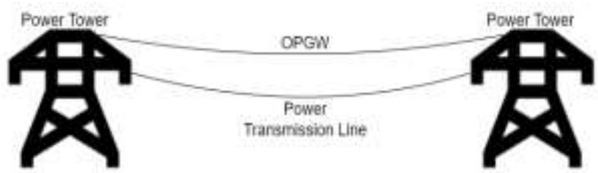

Figure 3: OPGW and Power Transmission Lines Between Towers

These towers can be utilized as a stand to install a small Local Access Network where this network consists of an outdoor switch that has a standard operating temperature range of from -40 to 75 ˚C. The outdoor switch is very small which means it can be mounted on the power tower without a major weight that affects the tower stability. The outdoor switch is powered up by a standalone DC power system which means the switch is going to utilize solar panels in the daytime and battery in the nighttime (This will be explained in depth later). In addition, it consists of a long-range camera that is powered up through Power over Ethernet (PoE). This long-range camera has a standard operating temperature range of from -40 to 75 ˚C. This Local Access Network has been designed and selected to be capable of working under very high temperature in order to adapt with Gulf Countries weather and environment. Figure shows the Local Access Network that consists of an outdoor switch and a long-range camera.

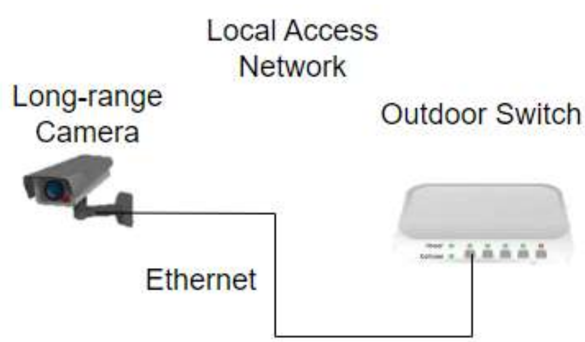

Figure 4: LAN that Consists of an Outdoor Switch and Long-range Camera

Each power tower has its own Local Access Network (LAN) which means each power tower has its own outdoor switch and long-range camera. Each Local Access Network is connected to another Local Access Network in the next tower through a single-mode fiber as it supports long distances between power towers. The edge LANs that are the nearest to the two cities are connected to edge routers (Wide Access Network) which is connected to the data center to process data. Figure 5 summarizes the network connections between LANs over power towers with WANs.

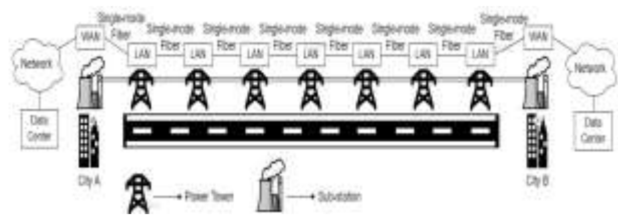

Figure 5: Network Connections between LANs over Power Towers with WANs

The LANs are designed as a network ring with two uplinks where if one uplink goes down, the LAN will go to the data center through the other uplink. This is done by configuring Virtual Router Redundancy Protocol (VRRP) where this protocol enhances the network connectivity and reachability to the data center by having two uplinks where one uplink is the primary and it is active while the other uplink is the secondary and it is standby. As a result, this enhances the network reachability from the long-range cameras in each LAN over the power towers to the data center where the data center has a sever that runs a YOLO algorithm.

YOLO (You Only Look Once) is an algorithm that processes the videos that are taken by the long-range cameras and then it divides these videos into frames and images. After that, it detects the objects that exist in these images and frames. YOLO algorithm trained to only detect camels, so it will ignore other objects in the images. YOLO sever will notify and send alert to 911 center to send a highway security team to the location through SMS server. The location can be identified by matching the IP address of the reporting long-range with its location for example if the IP address 172.10.10.10, the control center knows that the camera of this IP address covers certain range where the highway security team will be dispatched to.

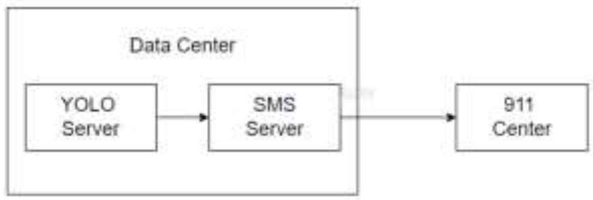

Figure 6: Block Diagram of YOLO System in Data Center

The outdoor switch in each LAN over the power tower is powered up by DC power. Therefore, there is a small DC power system that is mounted over each tower to power up the outdoor DC switch. The long-range camera will be powered up by PoE through the Ethernet port in the outdoor switch. The DC power system consists of solar panels, Lithium Iron Phosphate battery, Automatic Transfer Switch (ATS) and DC distribution board. The solar panels are utilized to power up the outdoor switch during daytime by converting the sunlight to DC electricity. Moreover, the solar panels have another function which is charging the Lithium Iron Phosphate battery where this battery is going to power up the outdoor switch during the nighttime. Lithium Iron Phosphate Battery is chosen as it has operating temperature range from -20 to 60 ˚C. The Automatic Transfer Switch (ATS) is utilized to transfer from primary power source (Solar Panels) to the secondary power source (Battery) during sunset and sunrise time. The DC Distribution Board is utilized to distribute the DC power from the solar panels to the outdoor switch and battery to power up the switch and charge the battery at the same time. Figure 7 summarizes the small DC power system.

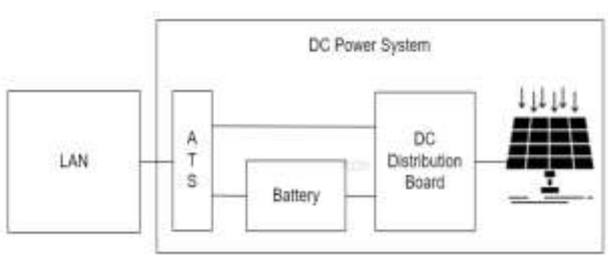

Figure 7: Design of DC Power System

Using the power towers between substations is going to eliminate the needs of constructing new towers as a stand for each LAN and its small power system, and as a result, this is going to significantly reduce the cost of building the system. Moreover, the existing fiber between power towers eliminates the need to lay new fiber which results in decreasing the cost of building the system.

III. DETAILED DESCRIPTION OF SYSTEM FUNCTIONALITY AND PROCESS

The Camel Detection System Over Optical Ground Wire Among Highways Between Cities, villages and towns is developed to enhance the process of preventing camels from crossing the highways by automating the process of detecting camels on highways and automating the process of reporting this to the highway security team to take immediate action and prevent any accidents and injuries resulted from car accidents with camels.

Figure 8 represents the current process of maintaining the fences by technicians which starts by traveling between cities to conduct visual inspections to evaluate the condition of the fences among the highways between cities, villages and towns. After that, the technicians may fix the fences during this inspection in case the fences require minor fixes. On the other hand, it may require scheduling another trip to the location again to fix the fences in case they require major fixes as the technicians may not have the materials needed to fix the fences. This is to ensure the fences are in good condition to prevent any camels on the highway which may result in deaths and injuries. This is a repetitive process to ensure the fences remain in good condition.

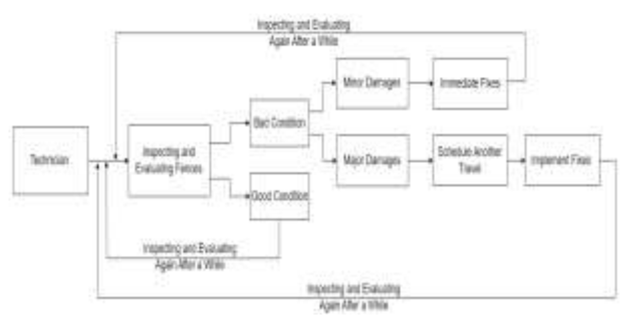

Figure 8: Current Process of Maintaining Fences

The above process is human based which result in increasing the need of more manpower which increase the operational and maintenance cost.

The current situation has another process which is used to take actions by the Highway Security Team if camels are detected to return camels in their area and prevent any deaths and injuries that resulted from car accidents with camels. This process is very slow and may take hours to return camels as it depends on reporting the cases manually to the 911 center through a phone call. Also, this human-based may got affected by slowness in contacting 911 Centre as the highway between cities may not be fully covered by GSM which resulting in a delay of reporting the case to the 911 center. Figure 9 represents serious actions and events in block diagrams based on the current process.

Figure 9: Actions Based on the Current Process

There are a few problems inherently associated with the current process and method:

- It is a human-based process and method.
- Require high number of operations center operators to monitor each communication channel between rigs and plants.
- Not real-time process and method that immediately detect and report camels on the highways which lead to immediate corrective actions before car accidents took place by the Highway Security Team.
- The operational and maintenance cost of constructing and maintaining the fences is high.

The revised method enhances and automates the process of detecting and reporting the camels on the highway by training a YOLO algorithm to detect camels by analyzing the videos that are received from the long-range cameras that are mounted over the power towers that are scattered among the highway between two different cities. The videos are going to be analyzed by dividing them into frames and images where YOLO is going to use a trained algorithm to analyze the objects in the images and frames to check if there are any camels crossing the highways.

The images and frames are going to be sent from each long-range camera to the YOLO server in the data center through Optical Ground Wire (OPGW) that connects the power towers to each other. This helps form several small LANs over the power towers that are connected to each through the OPGW. The first LAN, which is the closest LAN to the first city, is connected to a router that connects the long-range cameras to the YOLO server in the data center while the last LAN which is the closest LAN to the second city is connected to another router that helps provide a redundant uplink for these small LANs. This means there are two uplinks that help connect the long-range cameras reaching the YOLO server in the data center. One uplink is active, and the other uplink is standby.

Each LAN consists of an outdoor switch as outdoor switches can operate in temperature range of from -40 to 75 ˚C. The outdoor switch provides an ethernet connectivity to a long-range. The outdoor switch is powered up by DC power system where the DC power system consists of solar panels, Lithium Iron Phosphate battery, Automatic Transfer Switch (ATS) and DC Distribution Panel. The long-range camera is powered up through Power over Ethernet (PoE) from the ethernet port in the outdoor switch.

The components in the DC power system play crucial roles in ensuring power reliability for the LAN network during day and nighttime. For instance, solar panels have two roles where the first one is converting the sunlight into DC electricity to power up the outdoor switch while the other role is charging the battery during the daytime, so it can power up the outdoor switch during nighttime. The second part in the DC power system is the DC Distribution Panel where it works mainly in the day time as it has one input which comes from the solar panels, and on the other hand, it has two outputs where one output is used to power up the outdoor switch while the other output is used to charge the battery. The DC Distribution Panel ensures distributing the power to the outdoor switch and battery simultaneously. The battery is going to the power source that powers up the outdoor switch during nighttime as it is going to be in the discharging mode while it is going to be in the charging mode during the daytime as it will be charged by the solar panels. Lithium Iron Phosphate battery is going to be utilized as it can operate in temperature range of from -40 to 75 ˚C which means it can be installed in outdoor environment. The last power component in the DC power system is Automatic Transfer Switch (ATS) where this component has two inputs. The first input is the power that is generated from the solar panels which is considered the primary power source during daytime while the second input is the power that is generated from the battery during the nighttime. The ATS role is switching between the primary and secondary power source during sunrise and sunset time.

Figure 10 shows the DC power system during daytime and nighttime where the red lines represent the current flow to power up the system.

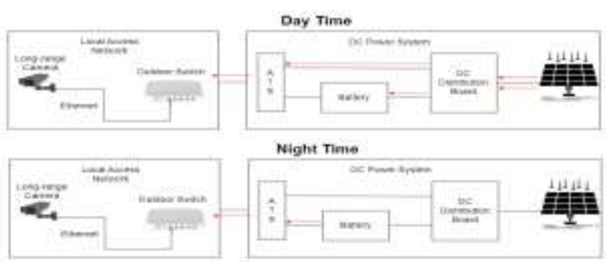

Figure 10: DC Power System During Daytime and Nighttime

An ethernet cable is utilized to connect the long-range camera to the outdoor switch as it supports the PoE feature which enables powering up the long-range camera.

Figure 11 represents the whole connection for the revised method. Starting with the outdoor switch, each outdoor switch has two uplinks that are used to connect the switch to the neighbor switches on the neighbor power towers. This is for each switch on the top of the power tower which forms a set of cascaded switches. A single-mode fiber the two uplinks as this type of fiber support long distances between the power towers. These sandwiched LANs on the top of the power towers are represented in the below drawing by four dots. The power towers that are the nearest towers to city A and city B are shown in the diagram below where it has two uplinks as well. The first uplink is connected to another switch while the other uplink is connected to a router. This makes the cascaded switches act as a loop with two uplinks to two different routers which is configured by using Virtual Router Redundancy Protocol (VRRP). This is to ensure reliable and redundant network connectivity to the data center. These two routers are connected to the network through fiber to be routed to the YOLO server in the data center. The YOLO server is going to analyze the frames and images to detect the existence of the camels on the highway. The YOLO server is going to notify the 911 center through SMS server to dispatch a Highway Security Team to the location to take corrective actions to prevent any injuries and death that resulted from car incidents with camels. The location can be identified by matching the IP address of the reporting long-range with its location for example if the IP address 172.10.10.10, the control center knows that the camera of this IP address covers certain range where the highway security team will be dispatched to.

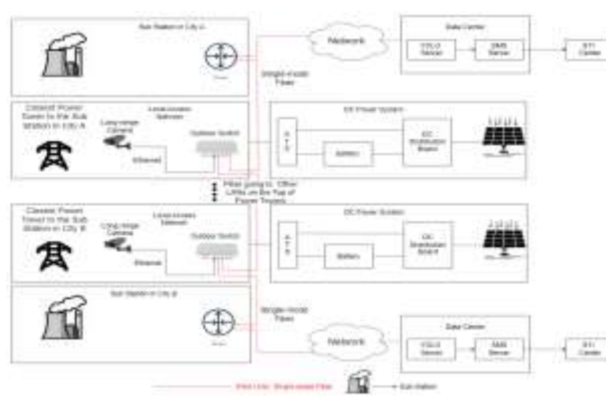
Figure 11: The Design and Connections for the Whole Revised System and Method

This invented solution results in some advantages such as:

- It automates the process of detecting camels on the highways.
- Reduce manpower needs as no need for technicians to monitor and check the fences.

- Real-time of detecting and reporting camels on the highways which lead to immediate corrective actions before car accidents took place by the Highway Security Team.
- Reduce the operational and maintenance cost that is spent on constructing and maintaining the fences.

IV. CONCLUSION

The ongoing issue of camel-related accidents on highways in Gulf countries—such as Saudi Arabia, Kuwait, Qatar, and the UAE—remains a significant safety hazard, leading to both fatal accidents and severe damage to vehicles. Traditional methods, such as constructing costly fences along highways, have proven ineffective in the long term. These fences require extensive resources for construction and continuous maintenance due to harsh environmental factors like sandstorms and high temperatures. Moreover, they do not fully eliminate the risk of camel crossings, resulting in recurrent accidents. As a result, a more efficient and sustainable solution is urgently needed.

The proposed solution leverages the existing infrastructure of power transmission towers, which are already installed along highways to transmit electricity between sub-stations. By integrating a Local Access Network (LAN) with long-range cameras and utilizing the YOLO (You Only Look Once) algorithm for real-time object detection, this system provides a cost-effective and scalable method to monitor and prevent camel crossings. The system uses solar-powered cameras mounted on power towers to detect camels in real-time, sending alerts to highway authorities via SMS when a camel is detected near the road. This approach significantly reduces the need for new infrastructure, thereby lowering costs while enhancing the system's operational efficiency.

To benchmark the effectiveness of this solution, performance metrics such as detection accuracy, real-time processing speed, and alert response time should be measured. Additionally, cost-effectiveness can be compared with traditional fence installation and maintenance over time. In terms of future enhancements, integrating machine learning models that improve detection accuracy under varying environmental conditions, such as sandstorms or low visibility, would enhance system reliability. Furthermore, the integration of next-generation 5G or low-latency communication technologies could accelerate real-time data transmission, enabling faster responses to prevent accidents. Additionally, expanding the network to include other animals, such as camels, goats, or livestock, could make the system even more versatile.

Ultimately, this innovative solution offers a promising framework for addressing animal-related road accidents in Gulf countries and could be adapted to similar challenges in other regions worldwide.

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