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Design and Implementation of a Convolutional Neural Network-Based Anti-theft System for Reservoir Aquaculture

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Abstract:

This study introduces an Anti-theft system for reservoir aquaculture leveraging a convolutional neural network (CNN), comprising front-end acquisition equipment, a cloud server, and terminal monitoring devices. The system primarily employs the CNN image processing capabilities of the infrared sensor module to detect and identify unauthorized individuals accessing the reservoir. Upon detection, it issues alerts via an audio input and output module and notifies the reservoir manager through terminal monitoring equipment. The system aims to utilize CNN to efficiently provide real-time anti-intrusion updates to the reservoir manager, thereby minimizing unnecessary monitoring time and reducing labor costs.

Keywords:

Convolutional Neural Network; Anti-theft System; Reservoir.

1. Introduction

At present, various types of reservoirs in my country will more or less breed some fish in the reservoir, and cultivating an appropriate amount of fish in the reservoir will help to improve the reservoir environment and also bring certain economic benefits.

The area of the reservoir is generally large, so most areas have no electricity, and it is inconvenient to install cameras; even if cameras are installed in some areas, people need to come to watch the cameras in real time to achieve the monitoring effect, and people's attention is very It is easy to disperse, which creates regulatory loopholes. Therefore, some people still use the incomplete loopholes of human guards combined with some cameras. Fishing or even fishing in the reservoir will reduce the number of fish in the reservoir and damage the ecological environment of the reservoir. ; For some farmers contracting the reservoir, it will also cause the loss of personal property.

In view of the above problems, this paper designs an Anti-theft system for reservoir aquaculture based on convolutional neural network, which can effectively prevent people from invading the reservoir and reduce the input of labor costs.

2. Convolutional Neural Network Reservoir Breeding Anti-theft System

The convolutional neural network reservoir aquaculture Anti-theft system proposed in this paper, the connection diagram is shown in Figure 1, and the system structure is shown in Figure 2. As can be seen from Figure 2 , the convolutional neural network Anti-theft system for reservoir aquaculture includes the front-end acquisition equipment, cloud server and terminal monitoring equipment of the reservoir Anti-theft system , and the front-end acquisition equipment also includes a single-chip control module that controls the operation of the front-

end acquisition equipment for detection. Infrared sensor module for the presence of people or animals in the monitored area, audio input and output module for dialogue for warning and dialogue. The cloud server includes a convolutional neural network processing unit that processes the images collected by the front-end collection equipment of the reservoir Anti-theft system. The terminal monitoring equipment is used to monitor the real-time status of the monitored area and present the situation of the monitored area to the reservoir manager.

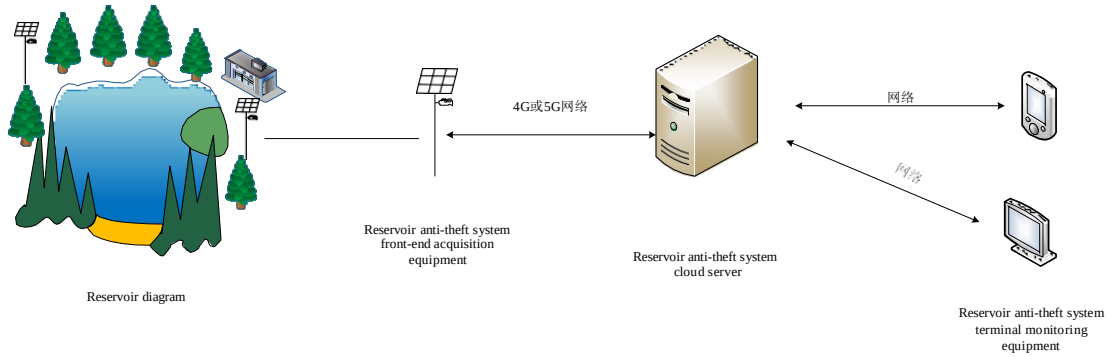


Figure 1. Schematic diagram of the convolutional neural network reservoir aquaculture Anti-theft system

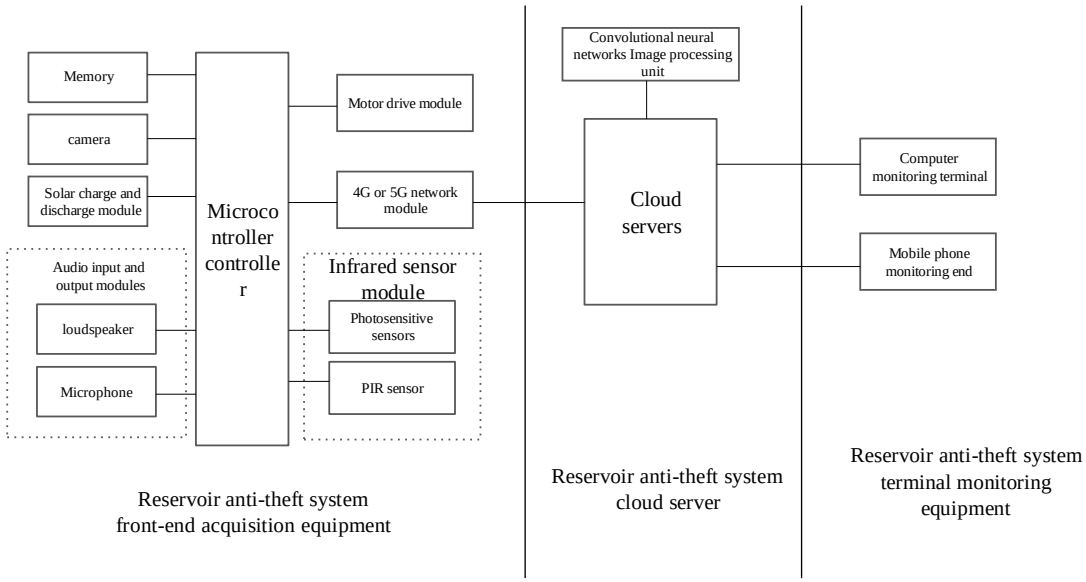


Figure 2. Structure diagram of the convolutional neural network reservoir aquaculture Anti-theft system

2.1. Front-end Acquisition Equipment of Reservoir Anti-theft System

The front-end acquisition equipment of the reservoir Anti-theft system is installed around the reservoir, as shown in Figure 1. Its function is to collect real-time image data of the corresponding area, determine whether someone has broken into the monitored area, and send information to the reservoir manager according to the situation. Commands from reservoir managers can also be received and executed.

The front-end acquisition module includes a single-chip controller, a convolutional neural network processing module, a camera, an audio input and output module, an infrared sensor module, a motor drive module, a solar charge and discharge module, and a 4G or 5G network transmission module.

The single-chip controller is the control center of the entire front-end acquisition device, responsible for controlling and coordinating each module in the front-end acquisition device. The single-chip controller can use the STM32 series of single-chip microcomputers.

The infrared sensing module is connected to the microcontroller controller, and the infrared sensing module is composed of a PIR sensor and a photosensitive sensor. The PIR sensor is generally used with a Fresnel lens with a focusing function. The function of the PIR sensor is to sense whether people or animals such as cats and dogs move in the monitoring area. When people or animals such as cats and dogs enter the monitoring area, the Fresnel lens's focused energy will change [1], at this time, the PIR sensor will send a signal to the single-chip controller. After the single-chip controller receives the signal from the PIR sensor, it will control other modules to carry out the next step; if the PIR sensor does not When the signal is received, the system is in a dormant state at this time, which can reduce the energy consumption of the entire system. The function of the photosensitive sensor in the infrared sensor module is to sense the change of the light intensity in the environment [2], which can help the solar charge and discharge module to sense the light intensity and perform the charge and discharge work.

The camera is connected to the single-chip controller for image acquisition of the monitoring area. When the PIR sensor in the infrared sensing module sends a signal to the single-chip controller, the single-chip controller controls the camera to obtain the real-time image of the monitored area and stores the real-time image in the memory. , and simultaneously transmitted to the convolutional neural network image processing unit in the cloud. In addition, the camera can also be rotated with the motor drive module to receive instructions from the terminal monitoring equipment to obtain a wider and more specific monitoring area.

Audio input and output modules, including speakers and microphones. When the convolutional neural network image processing unit located in the cloud server recognizes a person, the single-chip controller will send a signal to the speaker, instructing the speaker to sound an alarm to persuade the person who broke into the reservoir. When the terminal monitoring device issues a communication command, the speaker and the microphone can also be used as audio input and output respectively to establish communication between the front-end acquisition device and the terminal monitoring device.

The 4G or 5G network module is connected to the single-chip controller, which enables the front-end acquisition device to receive or send information and instructions. The image information is sent to the terminal monitoring equipment, and the network here can be any network sufficient to support the transmission data speed, such as 4G, 5G, and wired broadband [3]. The 4G or 5G network module enables the front-end acquisition equipment to easily connect to the Internet and transmit data in areas where it is inconvenient to arrange a WIFI network in the reservoir.

The solar charge and discharge module is connected to the single-chip controller to provide electrical energy to the entire front-end collection equipment. When the light intensity indicated by the photosensitive sensor in the infrared sensor module is suitable, the battery in the solar charge and discharge module is charged [4]. The existence of the solar charging and discharging module enables the front-end collection equipment to work normally in the non- electric area of the reservoir.

2.2. Reservoir Anti-theft System Cloud Server

The cloud server of the reservoir Anti-theft system acts as a transfer station for the communication between the front-end acquisition equipment of the reservoir Anti-theft system and the terminal monitoring equipment. If the reservoir manager wants to check the real-time status of the monitored area of the reservoir, he needs to use the mobile phone or computer terminal to send the information to the cloud of the reservoir Anti-theft system. The server sends an instruction, and the video captured by the front-end acquisition device in real time can be obtained only through the relay instruction.

The cloud server also deploys a convolutional neural network image processing model , which is responsible for processing the image data collected by the front-end acquisition equipment, and transmits the processing results to the front-end acquisition equipment and terminal monitoring equipment .

The convolutional neural network used here is the Faster RCNN network. This convolutional neural network has the characteristics of high detection accuracy and fast detection speed for intruders and animals in the reservoir [5]. The network structure of the Faster RCNN network is shown in Figure 3 . shown.

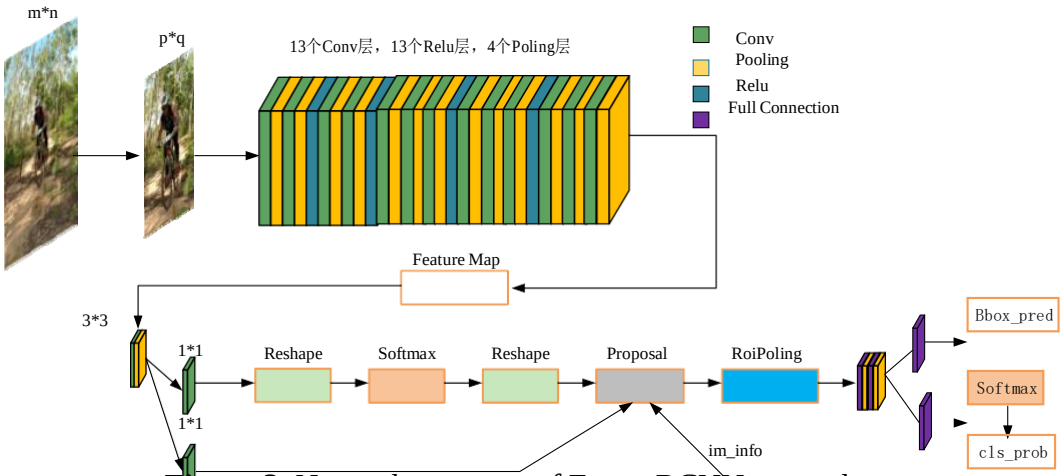


Figure 3. Network structure of Faster RCNN network

When the front-end acquisition device of the reservoir Anti-theft system collects a real-time image of the monitored area, as shown in Figure 3, it is a picture of a person riding a bicycle in the wild, and the collected image is transmitted to the reservoir in real time through the 4G or 5G network. The cloud server of the system, the trained convolutional neural network processing unit in the cloud server recognizes and processes it.

Before Faster RCNN convolves the image, the collected image must be preprocessed first, that is, it is cropped to the image size required by the network, and then the Feature Map (feature map) is obtained through the convolution operation of Faster RCNN, and then the feature map is sent to the RPN, that is, the regional candidate network [6], as shown in Figure 4 below.

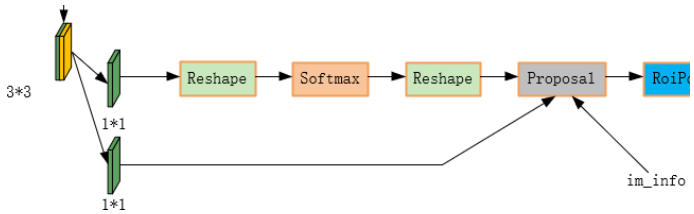


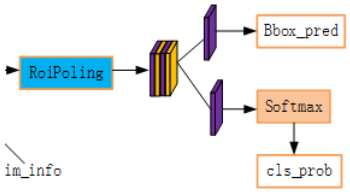
Figure 4. RPN network structure

Next, RPN is sent to RoiPoling for pooling [7], and then sent to the Classification network structure as shown in Figure 5 below for classification, and two results are obtained; one is to frame the target with a candidate frame, another get its classification result, in the reservoir Anti-theft system, only needs to judge whether the classification result is human. If it is a human,the detection result will be fed back to the front-end acquisition equipment and terminal monitoring equipment of the reservoir Anti-theft system. The front-end acquisition device of the reservoir Anti-theft system will send instructions to the single-chip controller, and the single-chip controller will control the audio input and output module to issue an alarm.

The terminal monitoring equipment sends warning information to the reservoir aquaculture manager. After receiving the warning message, the reservoir manager can control the front-end acquisition equipment through the terminal monitoring equipment, check the real-time monitoring status, or use the audio input and output module to communicate with the front- end acquisition equipment. Talk to the intruder with more specific warning instructions.

Figure 5. Classification part of the network structure

2.3. Terminal Monitoring Equipment of Reservoir Anti-theft System



The terminal monitoring equipment of the reservoir Anti-theft system is connected to the cloud server through the network. The network here can be any network sufficient to support the transmission data speed, such as 4G, 5G and wired broadband. The terminal monitoring equipment is divided into a mobile phone monitoring terminal and a PC monitoring terminal, that is, a personal computer monitoring terminal. Both monitoring terminals can view the images collected by the front-end acquisition equipment, and can also issue instructions to control the camera of the front-end acquisition equipment to rotate and obtain real-time acquisition. Images and voice calls with front-end acquisition equipment through speakers and microphones.

3. Conclusion

The convolutional neural network Anti-theft system is powered by the solar charge and discharge module, and the infrared sensor module is connected to the single-chip control module. When the infrared sensor has a signal, the single-chip control module controls the camera module to work, and the camera module transmits the captured image to the convolutional neural network. The network image processing unit performs identification. If no person is identified, no warning will be sent. When there is no signal from the infrared sensor, the system will be in a dormant state to prevent the monitoring equipment from running for a long time and power consumption; if a person is identified, trigger the The speaker alarms, and at the same time, it sends a warning of intrusion to the reservoir aquaculture manager through the wireless network module. The reservoir aquaculture manager can grasp the status of the camera monitoring area in real time through the mobile phone terminal, and can communicate with the front-end collection device through the terminal monitoring device. It is convenient to understand the intention of the intruder , which can effectively solve the problem of anti-whey in the non-electric area of the aquaculture reservoir , and at the same time reduce the investment in the labor cost of anti-intrusion in the aquaculture of the reservoir.

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