Indonesian Journal of Electrical Engineering and Computer Science
Vol. 31, No. 3, September 2023, pp. 1507~1514
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v31.i3.pp1507-1514

Intelligence feeder system for stray cats

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Article Info

Article history:

Received Jan 25, 2023
Revised May 7, 2023
Accepted May 9, 2023

Keywords:

Arduino mega 2560
Cat feeder
Jetson nano kit
Object detection
SSD MobileNet V2

ABSTRACT

Recently, the care of stray cats has become an important matter, given the difficulty for these animals to obtain food or water, whether in wild or remote areas, and this may cause the death of these animals. The aim of this work is to design and implement a low-cost feeding system for feral and indoor cats. The system is controlled by a jetson nano and arduino mega 2,560. The cat detection feeder system is built using the single shot multibox detector (SSD) MobileNet V2 algorithm. The system provides food and water for the cats. The SSD on jetson nano is implemented in real time. Jetson nano takes a picture using a webcam then runs the SSD algorithm. When a cat is detected, the arduino turns on a servo motor and a water pump. The system also includes a sim800l and GPS NEO-6M modules to send an alert message when the food and water tanks are empty. The message also contains the location of the feeder. When testing the system to determine the effectiveness of the functions, the SSD algorithm succeeded in recognizing cats, the system successfully provided food for the cats, and all parts of the device worked in high harmonic.

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1. INTRODUCTION

Stray pets are unowned animals that live outside without a home. Stray pets are either born in the wild or given up for adoption by their owners. Usually, there are many stray pets in public locations such as in institutions like hotels, hospitals, and universities where food waste is available [1]. Stray cats are becoming more prevalent globally. There are more than 200 million stray animals worldwide, according to estimates [2]. Where stray cats cause the extinction of at least 63 types from the wild worldwide [3]. In many nations, stray cats have a negative impact on the tourism economy for travelers, seeing hungry, ill, cats that plainly stray produces a bad impression and after experiencing it, many travelers are less likely to return there [4]. Stray cats have become one of the most the issue of contentious ones in animal welfare and animal control and are always debated topics. Numerous ways are presented for dealing with stray cats, for instance, the conventional ways are to trap and kill them. However, some government and private organizations oppose this way since it is inhumane and goes against the principles and values of the majority of nations [5]. Feeding stray cats presents a number of challenges, including the trouble of purchasing food, unwell cats, fear of feeders, and the increased ecological pressure placed on society as a result of increasing the breeding of stray cats quickly [6]. An automated cat feeder can replace the manual feeding method into a modern one.

Several systems are proposed by researchers for feeding food to pets and cats. Koley *et al.* [7] proposed a system for pet feeding. The system proposed by the researchers composes of a board (ATMEGA32),

which is utilized for controlling the system. Another part of the system is a cone-shaped container used for the purpose of depositing food in it. The system also includes a motor that is utilized to drive the opening and the closing of the conical feeding bowl. The person can give the timing of providing food to the pet.

Khatavkar *et al.* [8] proposed an intelligent food dispenser for feeding pets. An android application is used to control this food dispenser which controls the devices via the Wi-Fi module to dispense food. The microcontroller FRDM KL25Z is used in this study. To store the food, they use a storage box. This box contains a lid beneath the box. The lid is connected to a DC motor, which is linked to the FRDM microcontroller. The amount of food dispensed is determined by the amount of time which the lid is opening. After dispensing the food, the motor is rotated in another direction, therefore lid is closed. The android app is used to determine, how long the motor stays in the opening position.

Suffian *et al.* [9] developed a smart device for feeding pets, the arduino processor serves as the basis for the suggested system. Additionally, the suggested system comprises sensors and a feeding unit for storing and serving food. Feeding unit has square-shaped door that is controlled by a motor. The weight of the food has an essential impact on the feeding regime. The motor stops to feed the food when it attains a specific weight. The system was created to give food to farm-raised pets.

Kank *et al.* [10] suggested an automatic pet feeder using various sensors and arduino UNO. They used a distance sensor (proximity sensor) which is connected to arduino board. This sensor is used to sense or detect a pet near to the feeder. When the proximity sensor detects motion at a specific distance from the pet feeder, it sends an alert. In other words, the food is served as the pet approaches the bowl. For the locking system, a servo motor is used.

Adriansyah *et al.* [11] proposed a way of feeding pets based on web server as IoT application. They used several hardware components including arduino Uno, ESP866, ultrasonic sensor, push button, and servo motor. Ultrasonic sensor is used to measure the distance between container and sensor. In this work, there are two ways to operate the feeder for feeding food to pets, in the first way, push button is used which is connected to arduino, when user press the push button, the servo rotates to put the food into the container. In the second way, web server is used. This web server has information about the system including position of servo, the distance measured by ultrasonic sensor, and link for animal-feeding. When user clicks link for animal-feeding, the servo motor rotates to release the food.

Airikala *et al.* [12] investigated to build a feeder system with a solar voltage source. There are two microcontrollers used in this study, the first one is ESP8266 and second one is arduino. This system includes servo motor which is connected to arduino that opens the container. In this prototype, blynk application is used in order to automatically feed the animal. The aim of using ESP8266 is to communicate with the blynk application. Blynk is designed to create scheduling time for feeding and includes a button to turn on the servo for the purpose of open the container. A relay is used in this system to switch power between socket adapter and solar panel.

Anggraini *et al.* [13] presented a cat feeder system based on mobile monitoring system. They use the raspberry pi as microcontroller with various hardware components like webcam and stepper motor. The stepper motor and webcam are connected to raspberry pi. To control the operations of raspberry pi remotely, they connect it to the internet network and use the web browser or the web view on mobile for accessing the server which permits the process of feeding and monitoring. The stepper motor is used to move the feed value that allows the food to be out. They utilize buttons displayed on the web view on a mobile to control stepper motor function.

Fitriyani [14] proposed a prototype for monitoring and feeding cat using telegram application. He uses many components to build the prototype such as ESP8266, RTC DS3231, HX711 sensor, servo motor, and ultrasonic sensor. The RTC DS3231 is used by ESP8266 for food to be delivered automatically at a specific time. He uses an ultrasonic sensor to sense the existence or absence of a near object. When an object reaches a distance of less than 20 cm, the ultrasonic sensor will detect it, this means the cat nears and eats. In this prototype, the telegram is used to provide some information to the cat owner such as weight of food in grams, day, date, month, and cat approaches and is eating.

Beltran *et al.* [15] suggested of pet feeder with assisted of global system for mobile communication (GSM) technology. Arduino is used to control the system. In their study, they use SMS messages received from owners to provide food and water. Once the feeding process is finished, pet owners will receive a text message from the system informing them that the feeding is successful.

In this paper, fully automatic cat feeder system has been proposed which can be used to feed indoor and stray pets. The system is designed to detect the cat pets using pre-training single shot multibox detector (SSD) MobileNet V2 algorithm and provide the food and water using several supporting hardware components. The SSD MobileNet V2 object detection algorithm is implemented and tested using jetson nano kit. This paper is arranged as follows, section 1 presents the introduction and literature review, section 2 describes materials and methods, section 3 offers results, and section 4 gives conclusion.

2. METHOD

In this part, the main algorithm used in the proposed system, which is the SSD algorithm, will be explained. The structure of the device used in the proposed system will be clarified. In addition, an explanatory diagram of the device's working mechanism will be presented, where the electronic parts of the device will be discussed and their properties and role in the operation of the device will be explained.

2.1. SSD MobileNet V2

The single shot detector (SSD) method employs a convolutional network to produce a collection of bounding boxes with a fixed size, as well as scores for the existence of object classes in those boxes, followed by a step named non-maximum suppression to obtain the last detections. in the initial layers of the network which is called the base network, the network for high-quality image classification is used (network without its classification layers) [16]. The architecture of SSD MobileNet V2 object detection algorithm includes integrating the SSD and MobileNet V2 model as shown in Figure 1 [17]. In this network, Mobilenet V2 acts as the base network which is known as the feature extractor while SSD acts as the object localizer. The function of a MobileNet feature extractor is to extract the features from the images and produces a feature map that represents the crucial characteristics required for jobs involving classification or detection. SSD's detection model takes those feature maps to identify the class and bounding box of an object [18], [19].

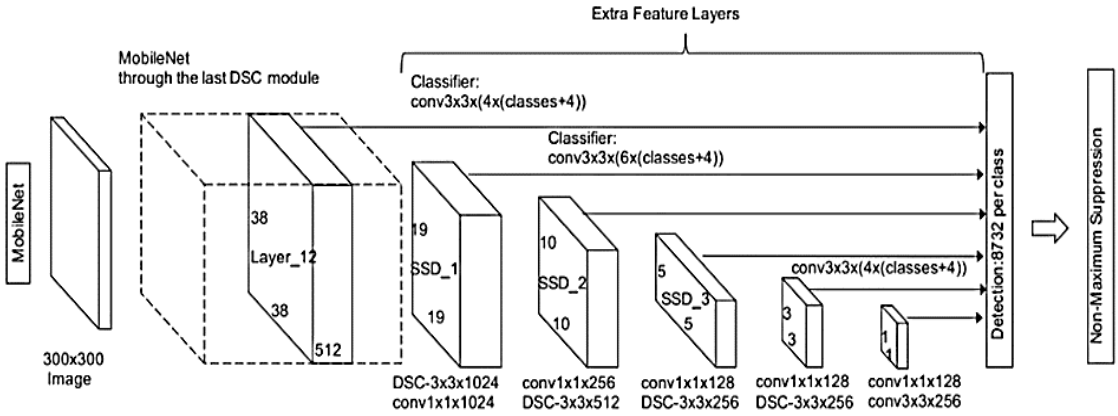


Figure 1. Architecture of SSD MobileNet V2 [20]

MobileNet V2 model is an enhancement compared to MobileNet V1. By including shortcut connections (residual connection) and utilizing depth separable convolution, MobileNet V2 may more effectively minimize the number of weights and biases in network and will increase speed of operation [21]. These benefits make model applied for embedded systems and mobile applications. Depth separable convolution is one type of decomposable convolution [22].

SSD network represents an object localizer. This network executes on top of the MobileNet V2 base network. This network uses the output from the MobileNet V2 in order to determine both of class and position of objects [18]. This network uses the MultiBox technique in a different way to function. It employs a series of 1×1 and 3×3 filters and the using of previous series of filters are to reduce dimensionality and for feature-rich learning. MultiBox uses priors that represent as a collection of predetermined bounding boxes with fixed sizes before the process of detection. These bounding box priors are put to the regions of the ground truth such that intersection over union (IoU) is more than 50%. To accomplish this, pre-computations are used, which indicate a rough likelihood of where the desired objects may appear in an image. SSD has excellent detection capabilities of large and small objects due to the image's segmentation into variously sized grids for the purpose of producing feature maps. After the base network, there are multiple convolutional layers with varying numbers of cells. Where a big number of cells make it easier to find objects in an image with smaller in size, and by other convolutional layers in the same image with a small number of cells due to increase in the cells' size, making it possible to find objects in an image with larger in size. Therefore, SSD is a very effective object detection technique for an input image and can detect a variety of object sizes because the output is directly linked to various numbers of convolutional layers. For each bounding box predicated in the output, a confidence score is provided for the label prediction and the predicted bounding box is taken in which having the highest value of confidence [20], [23].

SSD MobileNet V2 is pre-trained on the common objects in context (COCO) dataset to classify and detect several objects under complex conditions. This dataset has been widely used to address the problem of huge training datasets and learning models that depend on the image. This dataset considers as one of the excellent datasets for object detection data. In this dataset, there are 330,000 segmented images and 91 different object classes, all with incredibly accurate position labels [24].

2.2. System architecture

The design of the structure hardware components for an intelligent cat feeder system is shown in Figure 2. Dependent on the block diagram presented in Figure 2, the primary way to work the feeder system will be clarified via the flowchart which is shown in Figure 3. The goal of the system is the ability to detect cats using SSD MobileNet V2, then operates the hardware components for feeding food and water. The procedure to implement the algorithm will firstly switch on the webcam and implements the SSD MobileNet V2 object detection algorithm at the jetson nano kit, at this time, if a cat is detected, then the system will wait 15 seconds, after this period of time, the system is implemented object detection algorithm again, if the cat is already detected after this period, the water level sensor measures the quantity of water in the container. When the measured value is less than a predefined threshold, that means there is no water in the container, at this time, the arduino will measure the water quantity in the water tank using the second water level sensor which is inside the tank, if the tank contains water, then arduino will switch on the water pump motor to move water from tank into container.

Otherwise, arduino sends an alert message using GSM sim800L module that indicates that the water tank is empty, the message also has the x and y coordinates of the feeder. Then, by using ultrasonic sensor, the arduino measures distance between food container and sensor to find out whether the container contains food or not, if measured distance is more than threshold, it means that container is empty. In this case, the second ultrasonic will measure the food inside the food tank. When the distance is more than threshold, so it is confirmed that food tank is empty, therefore, arduino also sends an alert message using GSM module. Otherwise, the food valve will be opened by a servo motor. The benefit of using GY-30 sensor is to sense the intensity of light to switch on the light in order to permit the feeder system for providing water and food at period of night.

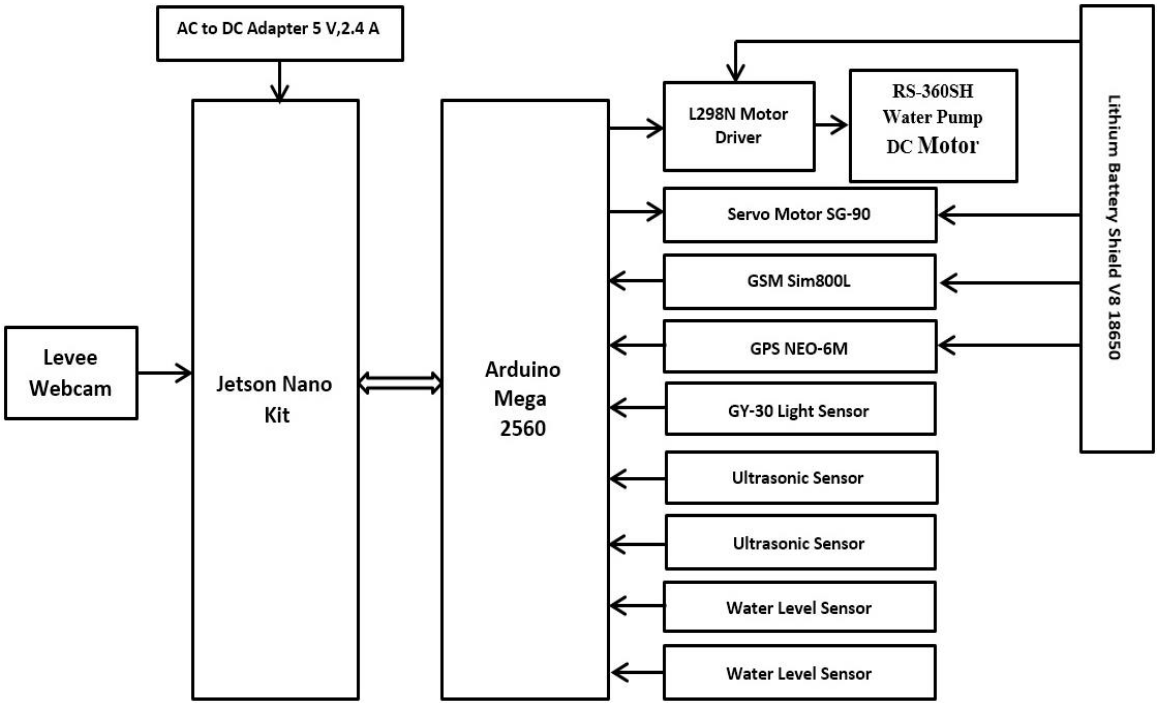


Figure 2. Block diagram of the system

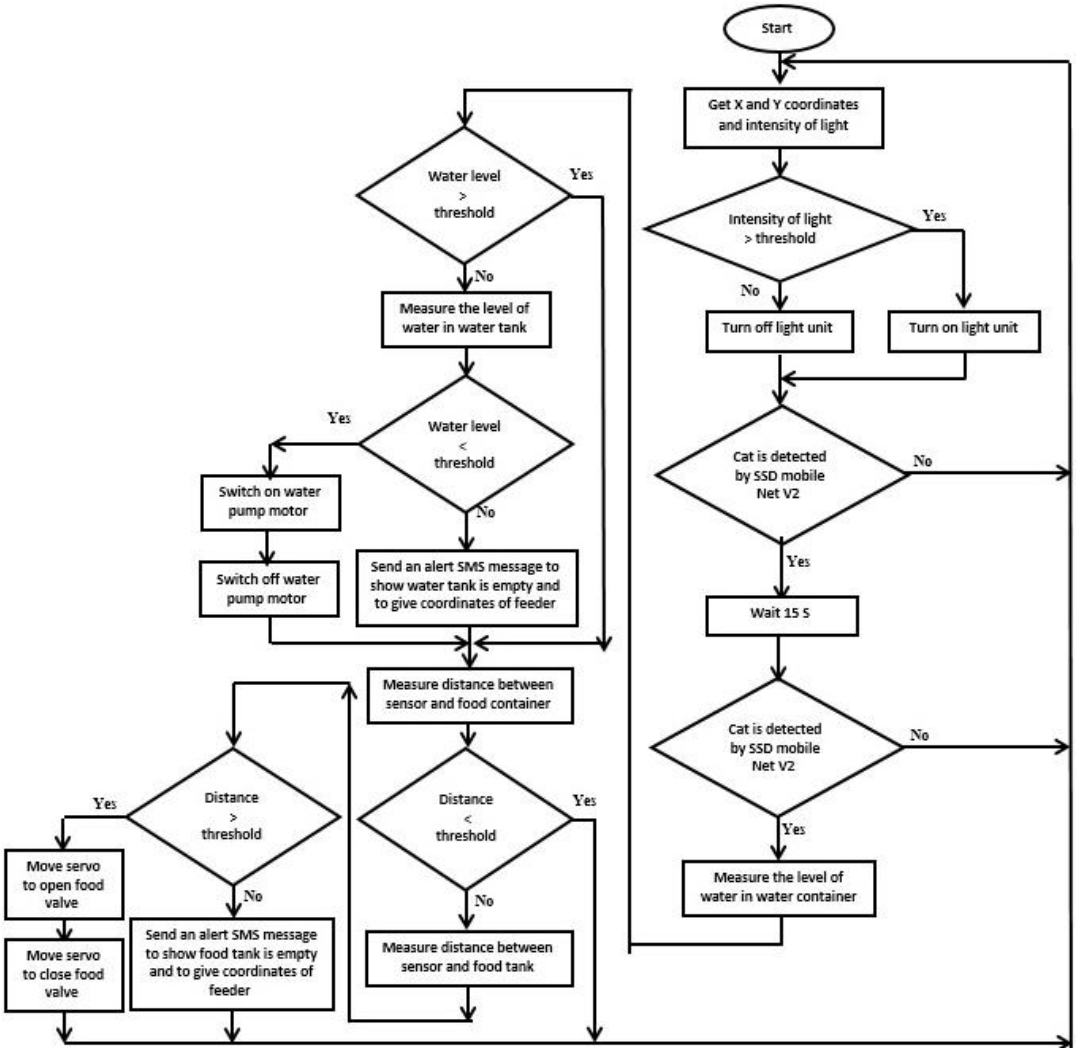


Figure 3. Flowchart of system

2.3. Feeder system design

Smart feeder system is design as shown in Figure 4 this feeder consists of three parts. The first one is a cube box that holds the electronic components including jetson nano, levee webcam, arduino mega 2,560, GSM sim800l, GPS NEO-6 M, GY-30 light sensor, L298N motor driver, and power supply. The second part is two rectangular containers, the first one is for food which has ultrasonic sensor and second one is for water which has water level sensor. The third part is a cube holder structure that consists of two tanks one for holding pet's food and other for holding pet's water. Inside the water tank, there are two hardware components, the first one is water pump motor and other is water level sensor. Finally, food tank has ultrasonic sensor, and servo motor.

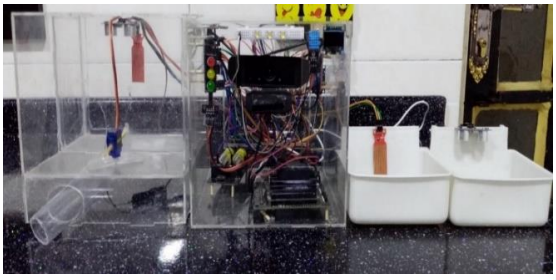


Figure 4. Cat feeder prototype

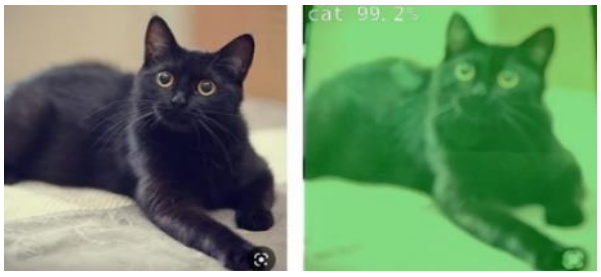
3. RESULTS AND DISCUSSION

Testing of the tool is done to see how effectively the intended functionalities perform. The test is also used to gauge how well these designed functions are performing. In the beginning, the SSD algorithm was tested on a set of images, in this test show the results in Table 1, the model has successfully detected the cat and its bounding box from images as shown in Figure 5. The test was carried out on a number of different cats in terms of color and type as well as shown in Figures 5(a)-5(d).

Table 1. Accuracy of detected cat

Test	Detection accuracy
Test 1 Figure 5(a)	Cat (98.9)
Test 2 Figure 5(b)	Cat (99.2)
Test 3 Figure 5(c)	Cat (93.2)
Test 4 Figure 5(d)	Cat (98.7)

(a)



(b)

(c)

(d)

Figure 5. Testing of cats images; (a) cat type 1, (b) cat type 2, (c) cat type 3, and (d) cat type 4

In Figure 5, it can be seen that the algorithm extracted the location of the cat within all images with a high degree of confidence. After the testing the SSD algorithm, another test is implemented on GSM modules as shown in Figure 6. And the GSM sends a message only in the event that there is a shortage of food or water inside the tanks, the content of the message also contains the location of the feeder which is obtained from GPS module. Finally, the GY-30 sensor is tested at two times once at daylight and another at twilight, and the values given by the sensor are 1,263 lux and 2.5 lux respectively [25].

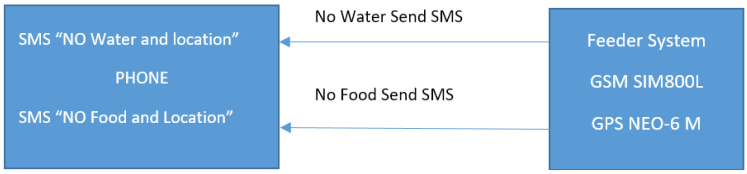


Figure 6. Warning message

4. CONCLUSION

At the end of this work, it can be said that the aim of this work presents building a cat feeder prototype to provide solution of feeding stray and owned cats problems. A prototype system is designed and implemented using several hardware components. The system is based on jetson nano and arduino mega 2,560. The system is designed to able detection cat using a SSD MobileNet V2 in real time then it will be feeding food and water. The system uses ultrasonic and a water level sensors to discover whether water and food tanks are empty or not in order to send an alert message when that one or both tanks are empty. Furthermore, there are another ultrasonic and water level sensors in the system, to measure the availability of water and food in containers. Besides, the designed prototype can work under condition night. Through the results of testing the system, it can be concluded that the system is characterized by high accuracy in controlling the material parts and achieving the desired goal. For future work, we suggest to develop the system for feeding other types of pets such as dogs.

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