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Drone Assisted Effective Pesticide Sprayer

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ABSTRACT

This paper is an intend to consolidate the review and perform literature survey on Drone Assisted Effective Sprayer. In this paper we consider how we use unmanned aerial vehicle (drone) in effective pesticide spraying using algorithms like CNN and YOLO. In India, Agriculture is a major sector of our economy. To increase the gross crop yield and to enhance the potency of the crops, the application of pesticides and fertilizers is crucial. To increase the speed and effectiveness of the spraying process, the use of drones are being introduced in agriculture all around the world. The same pesticide cannot be sprayed over different crops as their requirements differ. In this paper we analyse CNN and YOLO algorithms to find a specific crop and spray pesticide to a specific area of crop field.

Keywords : Drone, Agriculture, machine learning, Python, CNN, YOLO, Object Detection, OpenCV, Computer Vision, Pesticide Sprayer.

I. INTRODUCTION

In India, Agriculture is a major sector of economy. Pesticides and fertilizers play an important part in producing good quality crops. The use of pesticides in agriculture is essential to maintain the quality of large scale production. To increase the speed and effectiveness of the spraying process, the use of UAVs was introduced in the field of agriculture. However, various factors may reduce the yield and even cause damage to the crops. These factors include crop areas not being covered in the spraying operation, spraying pesticides in more than the required amount and spraying wrong peticides on the crops. Spraying pesticide to non crop areas may reduce the quality of soil and increase the risk of crop damage.

Pesticides are also known as agrochemicals, generally applied in agricultural crop fields to increase productivity, improve quality and reduce production costs. The use of UAVs to carry out the task of spraying pesticides can be beneficial to many reasons including – (i) to reduce human contact with the chemicals which helps to preserve human health (ii) to improve the performance of the spraying operation, avoiding the presence of chemicals outside the non crop areas. In recent years, there has been increasing interest in autonomous UAVs and its applications such as surveillance, search and rescue, infrastructure inspection. Visual object detection is an important component in such applications of UAVs, and is critical to develop fully autonomous systems.

Object detection is a technology that detects the semantic objects of a class in digital images and videos. For locating the objects in the image, we use Object Localization and have to locate more than one object in real time systems. There are various techniques for object detection, they can be split up into two categories, first is the algorithms based on

Classifications. CNN and RNN come under this category. In this, we have to select the interested regions from the image and have to classify them using Convolution Neural Network. As we have to run prediction on every region, this process becomes very slow. The second category is the algorithms based on Regressions. YOLO method comes under this category. In this, we won't select the interested regions from the image. Instead, we predict the classes and bounding boxes of the whole image at a single run of the algorithm and detect multiple objects using a single neural network. YOLO algorithm is fast as compared to other classification algorithms. In real time our algorithm process 45 frames per second. YOLO algorithm makes localization errors but predicts less false positives in the background.

II. LITERATURE SURVEY

The inspiration for the project comes from [1], where we learn about how technology is influencing the agricultural industry of the whole world and how the impact of introducing technological advancements in this field can increase the productivity and help in achieving 70% increase which is the amount we require. [2] talks about the innovations in the information and communications technology like "remote sensing technology" which can be applied in the field to pave the way for precision agriculture. The paper also provides a review on the use of unmanned aerial vehicles(UAVs) in the field of agriculture. It talks about which UAV system technologies are currently being used in agriculture and what type of data we can acquire by UAVs and the processing methods which can be used on the acquired data. [3] gives us a detailed look into the use of drones in the agricultural industry in India. It explains which methods and material to use to make our own drones, the methodologies and how the different components of the drone like flight controllers, electronic speed controllers (ESC) which control the BLDC motors etc. interact with the radio transmitters and receivers. [4] introduces machine learning and explains how we can use various machine learning algorithms to create a recognition system using image classifiers to help make the processes like crop monitoring, sprinkling system etc automated. [5] explains how we can use UAVs and wireless sensor networking to make an automated pesticide spraying tool. It explains all the requirements like routing protocol and cooperating sensing etc.

As explained in [6], object detection has been an important topic in the advancement of computer vision system. With the help of various deep learning techniques, the accuracy of in this field has been increased drastically. The paper explains how object detection works using classification and localisation. We use artificial neural networks(ANN) to create an object detection and recognition system as explained in [7]. To create such system, we use an artificial neural network known as "convolutional neural network"(CNN). [8] talks about how CNN works and how we can use it in our project to make a object detection system with high accuracy. [9] gives us a more detailed explanation about CNN works using multiple layers such as one inner layer, one outer layer and various hidden layers. The number of hidden layers differ based on the network. As explained in [10], we can use CNN for object detection in real-time. The paper explains how we can use a drone fitted with a camera to get a real time video feed and how we can use CNN for object detection and classification in real time.

For our project, we use an approach derived from CNN known as You Only Look Once(YOLO). As summarised in [11], yolo is a state-of-the-art approach for object detection as yolo detects objects in real-time by dividing the frame into a grid of 13 by 13 cells. [12] explains in detail about how yolo detects objects in real time by predicting 5 boundary boxes for each cell and how it eventually contributes to the confidence score which shows how certain the system actually is about the detected object. [13] talks about all the layers in yolo and how the cells are processed at each layer. It also talks about how we can train a faster version of yolo known as fast yolo which is designed to push the boundaries of object detection by making it even faster. We take the project done in [14] as an example for practical experience in which object detection is done to detect cars from a real time video taken from a drone. It explains how the anchor boxes work and the internal mechanism happens. [15] talks about how deep learning works and how we can use deep learning to make the object detection and classification process relatively faster.

III. EXISTING SYSTEMS

The existing system includes farmer spraying pesticides on the field by carrying large spray bottles with them. This can use a lot of health problems and is also time consuming. Another system is the use of small airplanes to spray pesticide in the field which is very costly for the small to medium level farmers. Now that drones are being introduced in agriculture, it solves the above problems. But the drones which are currently being used cause a lot of wastage of pesticides. Also, spraying excess of pesticide causes damage to the crops and spraying pesticides over plantless soil decreases the potency of the soil. Another problem while using the currently available drones is that it does not differentiate between different crops. Different plants need different types of pesticides for sustainance. Spraying wrong pesticide on the plants will do more harm to the crops than good. To avoid these problems, we are trying to come up with a new model.

IV. PROPOSED MODEL

The proposed model uses a trained drone for the purpose of spraying pesticide only where it detects a specific plant. After detecting the crops, the pesticide will we sprayed from a bottle attached to the drone. This model solves the problems found in the existing system. Our model avoids spraying pesticide over unused land which keeps the potency of the soil intact while also reducing the overall wastage. We also control the time interval between the sprays so we also reduce the over-spraying thus reducing pesticide wastage. And finally, as our model detects a specific plant, it avoids spraying wrong pesticides on the crops as we are spraying one type of pesticide over a specific type of plant. The differentiation between plants is accomplished by training the drone with the help of machine learning.

The training of the drone is done with the help of artificial neural networks. Artificial neural network is a part of machine learning which are basically computing systems which are vaguely inspired by the biological neural networks that constitute the animal brains. Such systems "learn" to perform tasks by considering various examples, generally without being programmed with task-specific rules. For example, in image recognition, they might learn to identify cats from images that contain cats by analyzing example images that have manually been labelled as "cat" or "no cat" and using the results to identify cats in other images. We use something similar to this to detect plants in the field by training our drone with a dataset containing details about the plants. In our model, we train our drone to detect the leaves and spray the pesticide at that place.

V. PROPOSED APPROACH

For our purposes, we use the Convolutional neural network. And to train the drone we use an algorithm called YOLO – You Only Look Once.

A. Convolutional neural network

Convolutional neural network(also known as CNN) is a neural network that consists of several different layers. These layers are called the input layer, the output layer, and the hidden layer. The Convolutional neural network is best used for recognizing various patterns such as edges, shapes, textures and colours.

There can be a number of hidden layers in Convolutional neural network where each layer acts like a filter that receives the input, transforms the input by using a specific pattern/feature, and sends it to the next layer.

As any other artificial neural network, the architecture of a Convolutional neural network is created to mimic the architecture the Neurons present in the Human Brain. The architecture of the Artificial Neural Network(ANN) was inspired by the organization of the Visual Cortex of humans. Individual neurons in the human visual cortex respond to each stimulus only in a specific and restricted region of the visual field known as the Receptive Field. A collection of such visual fields overlap to cover the entire visual cortex in the human brain [9].

Convolutional neural network s perceive images as volumes rather than flat canvases to be measured only by height and width. That's because the digital color images we use have a red-blue-green (RBG) encoding. Those three colors can be used by the system to produce the color spectrum which human eyes perceive. Any image provided to the system is ingested by the convolutional network as three separate strips of color which are stacked one on top of the other.
So, a normal color image is perceived by the convolutional network as a cuboidal box whose width and height are measured by the number of pixels present along those two dimensions, and the depth of the box is of three layers, one for each of the three strips i.e. RBG.

When we program a Convolutional neural network, the input used is called a "tensor" which has the dimension (no. of images) * (image height * image width * image depth). Then the image gets abstracted into a feature map after passing through a convolutional layer, which now has the dimension (no. of images) * (feature map height * feature map width * feature map channels) [8]. This process is performed to make the understanding and learning process of the system easier.

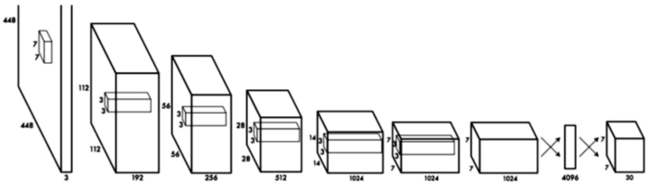

Fig. 1 Architecture of CNN

As we can see from the above figure, Fig. 1, shows the architecture of the CNN. This detection network consists of 24 convolutional layers followed by two fully-connected layers. And alternate 1 × 1 convolutional layers to minimize the features space from previous layers. The convolutional layers on the ImageNet classification task are pretrained at half the resolution (224 × 224 input image) and then the resolution is doubled for the detection purpose. The final result is the 7x7x30 tensor of predictions.[13]

A CNN is able to capture the Temporal and Spatial dependencies present in an image successfully through the application of various relevant filters. CNN performs a better fitting to the image dataset due to reusability of weights and the reduction in the number of parameters involved. CNN reduces the image into forms which are easier for the system to process, without losing any of the features necessary for best prediction. This comes in handy when we want to design an architecture which is not only fast at learning features but also is scalable to massive datasets. The Convolution Operation's main objective is to extract high level features from the input image such as edges. CNNs need not be limited to only one Convolutional Layer. The first layer captures the Low Level features such as gradient orientation, colour, edges, etc. The architecture adapts to the High-Level features with the added layers, giving us a network, which has the complete understanding of images provided in the dataset, similar to how we would.

B. YOLO: You Only Look Once

Object detection is one of the most challenging aspect in the field of computer vision. Recently, Deep Neural Networks have shown superior performance in this area. More recently, a You Only Look Once (YOLO) approach was proposed which mitigated the computational complexity issues faced by DNNs [1]. This is done by formulating the object detection problem as a single regression problem. This gives YOLO an advantage over traditional CNN.

You Only Look Once(YOLO) is a state-of-the-art, object detection system which detects objects in real time. Originally developed around 2015, it soon outperformed every other technique available at that time. YOLO has its own architecture based on CNN and anchor boxes and has proven to be an on-the-go object detection technique widely used for real world problems and with time, it has become faster and better.

From the below figure, Fig. 2, it can be seen how YOLO divides up any image into a grid of 13 by 13 cells: Each one of these cells is responsible for predicting 5 bounding boxes. A bounding box is the rectangle that encloses an object. YOLO also provides a confidence score that tells us how certain the system actually is that the predicted bounding box actually encloses some object.

Early detection systems repurposed classifiers or localizers to perform detection on an image. They applied the model to that image at multiple locations and scales. High scoring regions of the image were considered detections.

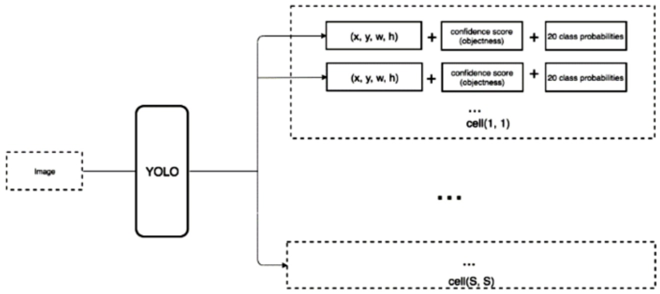

Fig. 2 Architecture of YOLO

YOLO uses a totally different approach. In YOLO, a single neural network is applied to the complete image. This network processes the image and divides it into grids of 13 by 13 cells and predicts bounding boxes and probabilities for each grid. These bounding boxes are weighted by the predicted probabilities [12].

It is also very important to predict the class probabilities. This probability is conditioned on the grid cell which contains one object. It means that if no object is present in the grid cell, then the loss function will not penalize it for a wrong class prediction [12]. Majority of these cells and boxes won't have any object inside and this is the reason why we need to predict class probability. In the next step, we remove boxes with low object probability and bounding boxes with the highest shared area. This process is called non-max suppression. The network predicts only one set of class probabilities per cell, regardless of the number of boxes. Adding the class predictions to the output vector, we get a tensor as the output.

YOLO trains on full images which directly optimizes the detection performance. This unified model provides several benefits over any traditional methods of object detection. YOLO is extremely fast as compared to the others. Because we frame the object detection as a regression problem, we do not need a complex pipeline. We simply run the neural network on any new image at test time to predict the detections. Furthermore, YOLO achieves more than twice the mean average precision of any other real time systems [11].

YOLO is made completely on the concept of plug-n-play, which means you can configure YOLO and detect any type of objects. YOLO does this by making use of configuration files under cfg folder. The configuration files end with a .cfg extension, which YOLO can parse. Each of these configurations have corresponding pre-trained weights.

Despite all the advantages, YOLO suffers from few known drawbacks related to the fully-connected layers [12]. that obstructs us from applying it to images with different resolution and diminishes the ability to distinguish small and close objects in groups that are critical for our tasks as we work with low quality images which include dense small groups of crops. First problem is that fully connected layers require fix input size and as this requirement propagates to input image, so we can't apply YOLO to arbitrary image without resizing it to sizes defined by net. Resizing can then lead to geometry deformations which could be harmful and then decreasing object sizes relates to problem with small objects.

VI. IMPLEMENTATION

A. Drone Architecture

The pesticide spraying drone consist of a Flight Controller, 4x ESCs, 4x Motors, 4x Propellers, RC Controller, Frame, Battery, Raspberry Pi 3 Model B+, FPV camera module and a spraying module. The flight controller is basically a small circuit board of varying complexity which directs the RPM of the motors in response to the input provided. The ESC (Electronic Speed Controller) connects the motors and the flight controller. The ESCs take the flight controller signal and draws power from the battery to spin the motors. There are four ESCs in total, one for controlling each motor of the drone. The architecture of the proposed system is as mentioned in the below figure, Fig. 3.

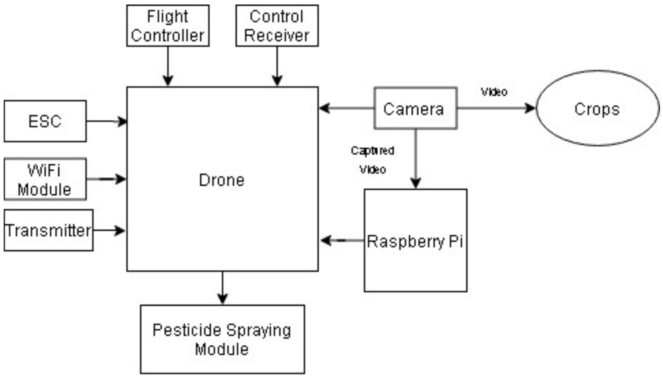

Fig. 3 Architecture of Proposed System

B. Object Localization and Detection

The drone assisted pesticide spraying system is driven by the YOLO algorithm. The YOLO algorithm is used for the detection of a specific crop in a farm. The drone hovers over the farm and detects the crops by capturing the video of the farm below it with the help of the FPV camera module that is attached to the front of the drone to get a clear view of the area below the drone. The video captured is then processed in real-time by dividing it into several frames and each of these frames is processed with the help of the YOLO algorithm which determines different objects present in each frame. This is determined by processing each frame and predicting a bounding box around each class for which it was trained for. In this case, the YOLO algorithm has been trained to detect several crops by providing the dataset containing several hundred images of crops. After the crops have been detected, they are sprayed over via the pesticide spraying module.

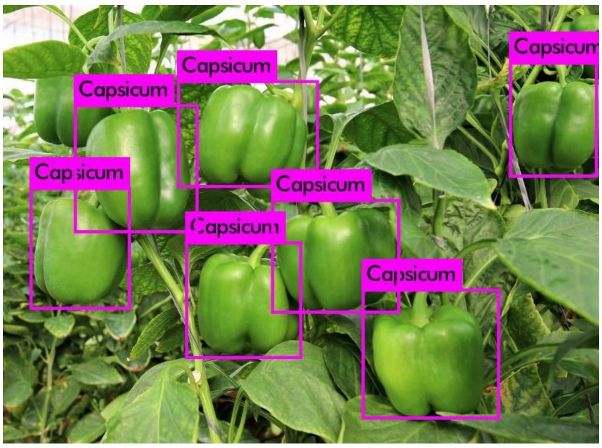

Fig. 4 Detection of Capsicum using YOLO v3.

The above Fig. 4, shows the successful detection of the capsicums using the bounding boxes. This model was trained using the dataset of capsicums so as to detect the capsicum plants and spray the pesticides on them once the detection is successful.

VII. CONCLUSION

In this paper we have described an architecture based on Unmanned Aerial Vehicles to implement spraying of pesticides in agricultural lands. The use of UAV's is cost effective way to obtain proper data on the farm to improve yields and overall productivity. The developed architecture helps to reduce the crop damage by controlling the UAVs in spraying operation without overlapping and applying pesticides to only crop areas. The use of drones to carry out the task of spraying pesticides can be beneficial in many ways including – i) reduces the human contact with the harmful chemicals which preserves human health. ii) It helps to maintain the quality of large scale production. iii) It saves time. The process of applying the pesticides to crop areas is controlled by means of the feedback from the wireless sensor network. Based on the results it is easy to find the area where to spray pesticide with required quantity.

VIII. FUTURE SCOPE

In a country like India, the use of drones for agriculture is still in its early stage. The future scope is to develop a system which is more user friendly to farmers and can easily adapt to technology. The developed system is only able to detect a single crop and in further development we can increase the number of crops to be detected. The future development can address the problem of self-adjustment of UAV routes when spraying chemicals in a crop field by considering the intensity and direction of the wind.

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