Implementing AHP Analysis to Increase the Detection Accuracy for Drone Detection System

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Abstract

Using a machine-imaginative and prescient detection primarily based on a deep mastering device, the observed mounted Darknet framework becomes aware of and makes the drone detection device. With the darknet, YOLOv3 set of rules, and OpenCV, the system developed on our pc to perceive drones based on the stay feed received from the camera or uploaded photograph. The system has become applied to tune and recognize drones in a unique history. The idea of AHP analysis was applied to the project to assist in using the excellent location to increase the system's dataset amongst three extraordinary places with four exclusive standards. The project methodology is based on four stages, amassing the dataset, annotating, training the system, and testing the gadget. The mission turned into identifying the drones with a mean achievement fee of 97% and 100% from live videos and uploaded images, respectively. The assignment confirmed that the detection turned into sturdy towards modifications in light depth and heritage consequences in specific environmental conditions because of the deep gaining knowledge of strength.

Keywords
AHP analysis, Drone System, Detection System using deep-Learning, Decision making for Drone.

1. Introduction
Over the beyond ten years, drone technology improvement for the cause that the first commercial drone changed into released at CES 2010 has created more than one man or woman and establishments to apply drones for a couple of features. We are presently dwelling in a time in which drones are being used for meal shipping, the cargo of products, and film filming and they may, in all likelihood, comprise more elements of our lives close to destiny. Although drones moreover pose a pinnacle-notch venture in terms of protection and prolateness inside the society (for each person and organization), and many drone-associated incidents are reported each day. These occasions had been known as the reputation of them want to hit upon and disable drones used for malicious intentions and started out up new studies and development regions for academia and corporation, with a market that is predicted to approach $2 billion by the usage of 2024. Laptop imaginative and prescient is a way of using imagery, both images, and video, to recognize devices. Computer imaginative and prescient duties require techniques to collect, store, interpret and apprehend the data in the pics. There are numerous strategies for computer imagination and prescience, including image popularity, object localization, object identification, semantic segmentation, and segmentation of instances, etcetera, and falls below the Architectures of object Detection. Your most effective look as soon as (YOLO) is a technique to object detection through the use of co-evolutionary neural networks for item detection. YOLO's key benefit is that it facilitates the monitoring of artifacts in real-time. "YOLO" pleasant seems in the entire picture once. As a result, the call "you look most effective once. This paper is an observation of the layout and characteristics of YOLO. Moreover, this paper is been used to explore the possibility of using AHP analysis to increase the accuracy of objects detection that's been already illustrated for the previous project that published under the same idea of our project.

While some of the principles used to come across UAVs had been adopted for drone detection, new methods had been counseled via this undertaking to deal with the challenges associated with detecting the very small and rapid-flying objects that pose a societal and protection threats created via drones the usage of deep learning and object detection. We analyze the effectiveness of this method regarding various factors (e.g., space, backgrounds, mild, and so on.). In this paper, we propose the following approach to recollect the dataset with applying the AHP analysis.

1.1 Objectives

The objective of this research is to do an enhancement on the dataset and to rebuild our own dataset for the drone's pictures/pics to be over 10,000 images, mainly for the only form of the drone we do have in our fingers. The new accrued dataset has to be sufficient to educate and check the system on the detection for/or any kind of drone we have or have the identical characteristic of our drones' kind. The photo we've need to be used in YOLO layout that allows us to have an awesome category of the chosen image and identification.

2. Literature Review

Recent related research and publications towards object detection and AHP analysis can be categories:

- Sustainable Development of Cultural Industry in Shaanxi Province of Northwest China: A SWOT and AHP Analysis:

This paper covers the subculture and landscapes of Shaanxi Province are representative of Northwest China. No matter the current prosperity of tourism, the sustainable improvement of cultural enterprise in Shaanxi Province is emerging increasingly. They analyzed the challenges and prospects for artistic enterprise in Shaanxi Province using the SWOT (strength, weak point, opportunity, and chance) method, in aggregate with the analytic hierarchy process (AHP). They used preferential data from local professionals who have an extensive and diverse understanding of the cultural enterprise of Shaanxi Province. The outcomes display that the strengths and possibilities for artistic enterprise in Shaanxi Province outweigh its weaknesses and threats. The specialists believed that the abundant resources in panorama and history are the foremost power and the many calls for inside the Chinese language market is a vital opportunity. Simultaneously, as the lag in social concept and governmental execution is diagnosed as a weak point for improving cultural enterprise, Western artistic effects and home/intra-regional competitions are considered crucial threats. The techniques' quantitative analysis indicates the energy/possibility strategy is the premier one for the sustainable improvement of Shaanxi's cultural industry.

- Application of recommendation system with AHP method and sentiment analysis:

In this paper, they advise on a device to assist human beings in making choices that suit their criteria. This study offers a device that could provide pointers for choice support people according to their standards, which can be internet-primarily based. The selection-making machine in this study uses the analytical hierarchy method (AHP) approach, which in this research, one of the standards is sentiment evaluation. Sentiment evaluation is the process of expertise, extracting, and processing textual statistics to get sentiment records from an opinion sentence. The opinion sentiment value of each opportunity can be blanketed within the AHP calculation to get the best opportunity guidelines in step with human beings' criteria. The result of this research is that the gadget can offer suggestions to people or users consistent with their standards and alternatives and public opinion at approximately every opportunity.

- Fuzzy AHP and Linear Programming Based Decision Support System for Logistics Service Providers Allocation:

In this paper, supply chain control is one of the maximum critical elements within agencies' achievement and operations these days. Inside the petrochemicals industry, and with heaps of shipments every year around the arena, the allocation system of logistics service vendors (LSP) may be crucial to its success in handing over the merchandise on time and with the desired fine. In this paper, a selection guide machine, DSS, has been developed to help a petrochemical organization optimize shipments allocation to Logistics service companies' LSP's on a month-to-month and weekly foundation. The bushy Analytical Hierarchy procedure FAHP became used to perceive the unique standards and their corresponding weights to be used for the LSP's ranking. Those weights were used to formulate a Linear Programming version that assigns the foremost variety of shipments LSP's. After using the brand-new choice help tool, the entire value has been extensively optimized. The LSP allocation process has been automated, which saves the selection makers time and assists avoid errors.

- IT2FS-DEMATEL-AHP-TOPSIS Multi-Criteria Hybrid Approach to Decision Making: A Selection Case Study and Criteria Assessment for Air Control Radar Positioning:

In this paper, the standards for selecting air traffic manipulates (ATC) radar role that offers effectively fulfilled radar positions in air traffic control are decided and evaluated. Using the questionnaire, professionals agreed on the preliminary criteria for selecting the radar function. Moreover, the hybridized DEMATEL-AHP-TOPSIS model was modified using the c programming language type-2 fuzzy sets (IT2FS). Much less crucial standards have been removed utilizing the IT2FS-DEMATEL method. The last criteria prioritization was carried out using the IT2FS-AHP technique, and a multi-criteria selection-making model was proposed. Of the four ATC radar positions supplied, the ideal function turned into a decided-on to aid using the IT2FS-TOPSIS approach. Validation of model changed into carried out with the assistance of Fuzzy and the IT2FS modified techniques: TOPSIS, COPRAS, and MABAC. A sensitivity analysis turned into accomplished through 36 scenarios of modifications within the standards' weights.

- Drone detection by acoustic signature identification:

In this paper, the standards for the selection of air visitors control ATC) radar position that offers effectively fulfilled part of the radar in air traffic manipulate are determined and evaluated. Using the questionnaire, professionals determined the initial standards for choosing the radar feature. Furthermore, the hybridized DEMATEL-AHP-TOPSIS model was changed using the usage of the C language type-2 fuzzy sets (IT2FS). Much less vital standards had been eliminated by using the IT2FS-DEMATEL method. The last measures' prioritization changed into carried out using the IT2FS-AHP method, and a multi-standards choice-making model was proposed. Of the four ATC radar positions provided, an appropriate function became decided on with the valuable resource of using the IT2FS-TOPSIS approach. Validation of version modified into carried out using Fuzzy and the IT2FS modified strategies: TOPSIS, COPRAS, and MABAC. A sensitivity evaluation was finished through 36 situations of modifications in the requirements' weights.

3. Methods

The principal factors to make this mission successful are the hardware and the software program of the system. The software we are using for the detection gadget might be Darknet, YOLOv3, and OpenCV. These three applications could help us make the detection machine less complicated and more manageable for detecting drones and growth. Additionally, it would be conducive and clean to make any changes to the detection drone type. However, the hardware could be NVIDIA Jetson Xavier, The Intel® RealSense™ intensity digicam D435 collection, and Multi-turn Torxis Servo, a commercial-grade Servo. The three decided on hardware are essential for the gadget to make sure to process the widget, figuring out, and searching the drones. The description and sequence of stages have been implemented to start our project are illustrated it in figure 1.

Moreover, using AHP analysis to determine the suitable location to recollect the dataset and increase the previous dataset as well. Also, darknet neural network framework with YOLOV3 set of rules with custom constructed dataset to hit upon drones, amassing information in the format of films and convert it to snapshots from the field, 80% of the gathered facts can be used to teach the neural network and the ultimate 20% to check it.

The Analytic Hierarchy technique (AHP) is a concept of measurement for coping with tangible and intangible standards that has been implemented to numerous areas, such as decision idea and warfare decision. The AHP is a trouble-fixing framework and a systematic manner for representing any trouble elements. The AHP is based totally on the subsequent 3 principles: decomposition, comparative judgments, and the synthesis of priorities. The AHP starts off evolved by using decomposing a complicated multi-criteria hassle into a hierarchy wherein every degree includes a few conceivable elements, which are then decomposed into every other set of elements. The second step is to apply a dimension methodology to establish priorities a number of the factors within each stage of the hierarchy. The third step in the usage of the AHP is to synthesize the priorities of the elements to establish the general priorities for the decision options. The AHP differs from traditional selection evaluation methodologies by means of no longer requiring selection-makers to make numerical guesses as subjective judgments are easily blanketed in the method, and the judgments can be made totally in a verbal mode.

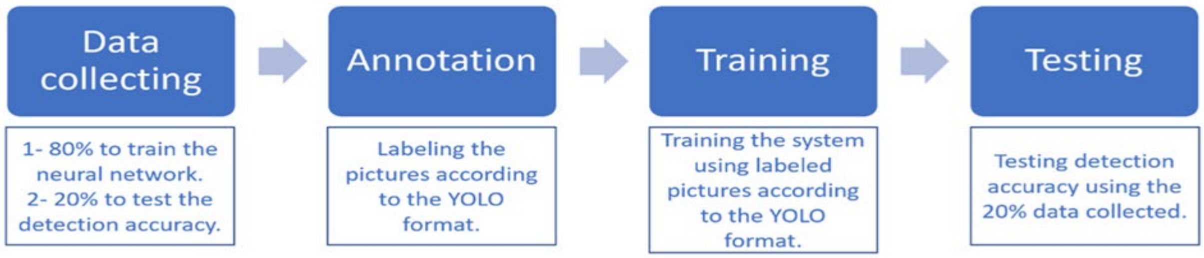

Figure 1. Stages for Enhancing Our Drone Detection System

<u>AHP analysis:</u>
To build up our new dataset for our project, we have had used the Analytical Hierarchy Process analysis (AHP) to help us where to go and collect the data from the field. The main criteria used in this analytical process were four: Distance, Light level, Background, and Altitude. We mean by the distance the space we can go far from the placed camera with the drone. We can say, moving forward and backward from the camera. The light level played an essential role in this study, where we can use different light levels such as, in the morning, in the evening, or at night. The third criterion was the background. The environment is fundamental since the image will be labeled later on, which will affect image quality, such as trees and cars once we feed the system. The fourth criterion is altitude. This is where we can go high with the drone in the sky to have different backgrounds with different drone angles. Moreover, comparing these criteria with the three places, we consider that those places are the best to go with, and gathering the needed dataset is to build our system. These places are Alfaisal University, My Home, and Public Gardens. The preferency level we have used is as in Table 1. Pairwise comparisons among objectives is shown in Figure 2.

Table 1. Levels of preferencies

PREFERENCE LEVEL	VALUE
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

	Distance	Light level	Background	Altitude	Normalized matrix				Weights	Product	Ratios
Distance	1	2	2	4	0.4444	0.5660	0.3226	0.2667	0.3999	1.7334	4.3342
Light level	1/2	1	3	5	0.2222	0.2830	0.4839	0.3333	0.3306	1.4723	4.4532
Background	1/2	1/3	1	5	0.2222	0.0943	0.1613	0.3333	0.2028	0.8463	4.1730
Altitude	1/4	1/5	1/5	1	0.1111	0.0566	0.0323	0.0667	0.0667	0.2733	4.1003
										CI	0.0884
										CI/RI	0.0982

Figure 2. Comparisons Among Objectives

We can see from the figure 2 that the normalized matrix can be calculated by having the sum of each column divided by the number of specific criteria. For example, 1/(1+1/2+1/2+1/4) = 0.4444. We'll be repeating the same thing with each number till we get the normalized matrix with objectives. Then, we will be having the average of each raw in the weight's column. Then, we will use the multi-lectionary matrix between the original numbers and the weights, and since they are 4x4 matrix and 4x1 matrix, they will be working. To get the numbers in the ratio column, we will divide the product's number on the weight respectively for each raw. After that, we have to calculate the Critical Index, which's equal to the average of the whole column minus N "which's equal to 4" divided by N-1. We must obtain the CI below 0.1 to have a good result of our estimated numbers and not deviate. Moreover, to ensure more about the results we were having, we must use the formula of CI/RI, which's equal to CI/0.9. Pairwise comparisons among Places on Distance is explained in Figure 3.

	Alfaisal Uni.	Home	Public Gardens	**Normalized matrix**			**Scores**	**Product**	**Ratios**
Alfaisal Uni.	1	2	4	0.5714	0.6154	0.4444	0.5438	1.6768	3.0838
Home	1/2	1	4	0.2857	0.3077	0.4444	0.3460	1.0590	3.0612
Public Gardens	1/4	1/4	1	0.1429	0.0769	0.1111	0.1103	0.3327	3.0166
								CI	0.0269
								CI/RI	0.0464

Figure 3. Comparison Among Distance

In this step, we will be repeating the same things we have done pairwise among the objectives in comparing Places with distance. Pairwise comparisons among Places on Light level is shown in Figure 4. In this step, we will be repeating the same things we have done pairwise among the objectives in comparing Places with light level. Pairwise comparisons among Places on Background is shown in Figure 5.

	Alfaisal Uni.	Home	Public Gardens	**Normalized matrix**			**Scores**	**Product**	**Ratios**
Alfaisal Uni.	1	2	3	0.5455	0.6154	0.3750	0.5119	1.6160	3.1565
Home	1/2	1	4	0.2727	0.3077	0.5000	0.3601	1.1278	3.1315
Public Gardens	1/3	1/4	1	0.1818	0.0769	0.1250	0.1279	0.3886	3.0380
								CI	0.0543
								CI/RI	0.0937

Figure 4. Comparison Among Light level

	Alfaisal Uni.	Home	Public Gardens	Normalized matrix			Scores	Product	Ratios
Alfaisal Uni.	1	9	7	0.7975	0.8571	0.7000	0.7849	2.5467	3.2447
Home	1/9	1	2	0.0886	0.0952	0.2000	0.1279	0.3895	3.0443
Public Gardens	1/7	1/2	1	0.1139	0.0476	0.1000	0.0872	0.2633	3.0199
								CI	0.0515
								CI/RI	0.0888

Figure 5. Comparison Among Background

In this step, we will be repeating the same things we have done pairwise among the objectives in comparing Places with Background. Pairwise comparisons among Places on Altitude is shown in Figure 6. In this step, we will be repeating the same things we have done pairwise among the objectives in comparing Places with Altitude. Determining the best place of the selected places is shown in Figure 7.

	Alfaisal Uni.	Home	Public Gardens	Normalized matrix			Scores	Product	Ratios
Alfaisal Uni.	1	7	2	0.6087	0.6364	0.6000	0.6150	1.8481	3.0049
Home	1/7	1	1/3	0.0870	0.0909	0.1000	0.0926	0.2779	3.0007
Public Gardens	1/2	3	1	0.3043	0.2727	0.3000	0.2924	0.8777	3.0023
								CI	0.0013
								CI/RI	0.0023

Figure 6. Comparison Among Altitude

Matrix of scores	Distance	Light level	Background	Altitude	Weighted scores
Alfaisal Uni.	0.5119	0.785	0.544	0.615	0.6155
Home	0.3601	0.128	0.346	0.093	0.2627
Public Gardens	0.1279	0.087	0.110	0.292	0.1218

Alfaisal Uni. has the highest score

Figure 7. Result of AHP and Comparisons

In order step to get the highest score, we have to do the multiplication on matrix with the scores with the weights as shown in figure 2. After doing the matrix multiplication, we have found that the Alfaisal university has the highest score among all other two places we have chosen. Which is fulfilling our demand and need that we have to recollect our dataset and proceed with the project to increase our system for detection on drones.

4. Data Collection

After applying the AHP analysis, we went to Alfaisal university to recollect and increase the dataset we have been gathered as shown in figure 8, figure 9 and figure 10. The collected dataset so far, about 11,000 images, which helps us to have a good detection accuracy at the end of the of the project. As in the method step, we had divided the recollected dataset into 80% for retraining the system for detection, and 20% for testing the system for detection based on the recollected dataset. Also, the uncleared and not suitable images that can't be used in the system were deleted and removed.

Figure 8. Recollecting Data from Field

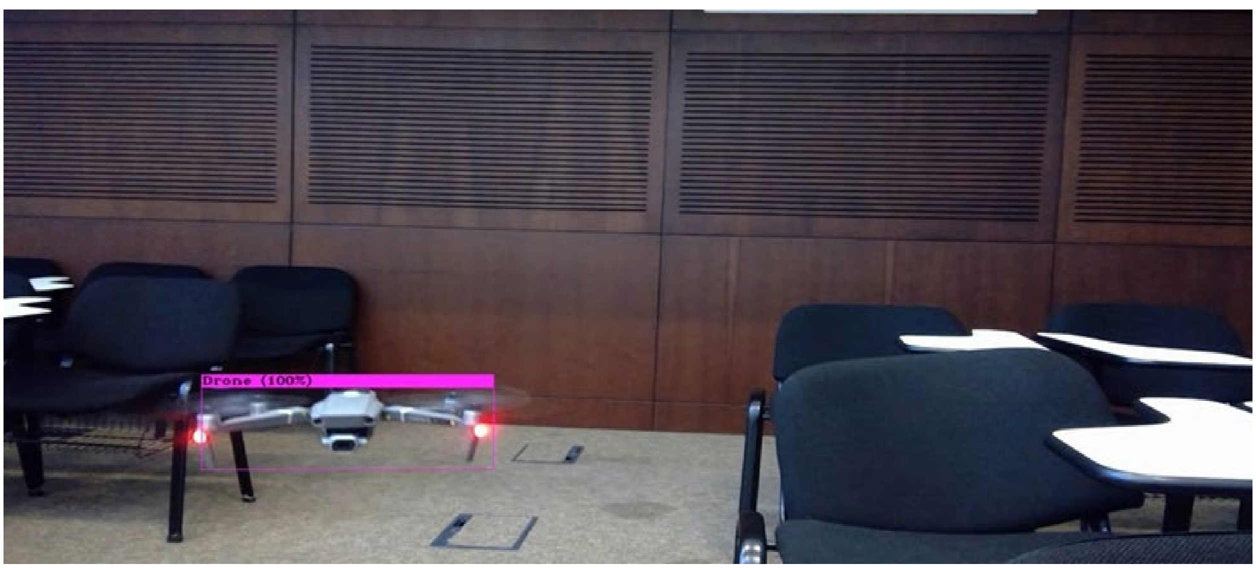

Figure 9. Another Picture from Recollecting Data from Field

Figure 10. Another Snapshot from Collecting Data from Field

5. Results and Discussion

This project and work achieved its goals and purposes of reaching a high detection accuracy percentage of the drones and it can detects the drones with an average accuracy of 97% for near and far distances around 60 meters, we still want to recollect more data to benefit us in the detection and optimize the system on far further distances and altitudes and to validate the progresses of our project on framework, particularly for deferent kinds of drones shapes and designs that are factory-made from diverse productions.

5.1 Numerical Results

In various problems, such as occlusion, lighting adjustments, sunshades, and partial visibility, the system became paintings. With the usage of extensive and detailed datasets, the proposed technique was examined and proved a massive improvement in modern-day accuracy and velocity compared to the three state-of-the-art strategies using primary hardware and GPU platform. The system operates in actual times and with high accuracy percentages. As a numerical result for our system that has been enhanced its accuracy percentage by using the AHP analysis for our dataset, we can find the previous result the was gathered from field and the new results that have been collected and calculated in the following table 2, table 3, and table 4.

Table 2. Old Percentages of Detection vs Trails

	5 Meters	10 Meters	15 Meters	20 Meters	Average accuracy for the trials
Trial number 1	99%	87%	71%	62%	80%
Trial number 2	98%	80%	85%	66%	82%
Trial number 3	95%	99%	41%	51%	72%
Trial number 4	97%	82%	88%	80%	87%
Average accuracy for each distance	97%	87%	71%	65%	80%

Table 3. New Percentages of Detection vs Trails After Enhancement

	5 Meters	10 Meters	15 Meters	20 Meters	Average accuracy for the trials
Trial number 1	100%	100%	100%	100%	100%
Trial number 2	100%	100%	100%	100%	100%
Trial number 3	100%	100%	100%	100%	100%
Trial number 4	100%	100%	100%	100%	100%
Average accuracy for each distance	100%	100%	100%	100%	100%

Table 4. New Detection Percentages vs Trails on Long and New Distances

	15 Meters	30 Meters	45 Meters	60 Meters	Average accuracy for the trials
Trial number 1	100%	100%	99%	89%	97%
Trial number 2	100%	100%	100%	88%	97%
Trial number 3	100%	100%	98%	89%	97%
Trial number 4	100%	100%	100%	84%	96%
Average accuracy for each distance	100%	100%	99%	88%	97%

In tables 2 and 3, we can see how the average accuracy of the system has been reached very high percentages, compared with the old percentages of the system before the enhancement of AHP. In the tables 2 and 3, we can see how the average detection accuracy reached 100% after it was 80%, this significant increasement of detection accuracy will assure the proper detection and operation on near distances below or equal to 20 meters. Moreover, the good impact of increasing the dataset reached out to help increase even the distance of detection to be reaching 60 meters with an average detection accuracy of 97% overall as shown in table 4.

5.2 Proposed Improvements

This research is able to be improved by increasing the dataset and using different places with different backgrounds and day lights. Since this is a supervised machine learning system, the improvement on it is continuous and applicable as well as its adjustable. With the three main criteria background, light level, and distance of image classification/detection systems, the system is learning on detection based on these criteria by using the annotating images on drones. Also, using different types of drones such as, f69 discovery 2 or 990 AeroVironment Wasp IIIs is applicable in order step to supervise the system on detection different types of drone’s shapes.

6. Conclusion

In conclusion, it is recognized from the evaluations of different articles that YOLO is the handiest and pleasant structure for any form of detection of actual-time objects. YOLO is simple to include, clean to recognize, and strong. Because it generalizes properly, it could be used in any app. the rate assessment with different CNNs is likewise provided in this study. However, the darknet is one of the important pieces of equipment that helped us to make our paintings successful in the detection of drones. This undertaking is on keeps development, and the next steps for us are using exclusive types of drones with distinct versions and designs, that is for the cause of increasing our dataset and additionally, increase the objects to be diagnosed of our detection system. The choice help tool used in this paper, the Analytic Hierarchy method, gives a systematic and flexible framework for analyzing the impact of things, together with the historical past, light stage, distance, and altitude. The flexibility of the AHP permits choice-makers to confirm the approach to match the particular occasions of a certain state of affairs. The AHP makes it viable to consist of each qualitative and quantitative element within the evaluation as well as subjective judgments by the choice-makers.

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