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Fitsbot (Fire Detection Smart Robot) Innovation in the Development of Drone Technology in Mitigation of Peat Forest Fire

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ABSTRACT

Indonesia's forests continue to shrink due to forest fires. Indonesia's deforestation rate for 2019-2020 is 115.5 thousand hectares. The use of manual methods for forest monitoring is considered less effective because it requires a long time and a lot of resources. Natural and weather conditions affect the implementation of forest monitoring to prevent forest fires. Based on these problems, the author offers an innovation in FITSBOT (Fire Smart Robot) technology. The research method used is Research and Development (R&D) with the stages of Analysis, Design, Development, Implementation and Evaluation. The result of this research is a quadcopter with integrated artificial intelligence based on YOLO for forest monitoring. This technology is expected to facilitate forest monitoring in order to take preventive measures and early detection of forest fires.

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INTRODUCTION

Indonesia's forest area continues to shrink every year, referring to the calculations of the Directorate General of Planning, Ministry of Environment and Forestry, Indonesia's deforestation rate for the 2018-2019 period reached 462.4 thousand hectares and 2019-2020 became 115.5 thousand hectares. One of the causes of forest loss is forest fires.

Forest fires greatly impact the destruction of natural ecosystems and cause the extinction of flora and fauna that have habitat in the forest (Arum, I. S., Ayu, I. G., Rachmi, K., & Najicha, F. U. 2021). One solution that can be done to prevent forest fires is monitoring forest areas which must be carried out regularly. Periodic forest monitoring requires an effective and efficient technological innovation.

UAV (Unmanned Aerial Vehicle) is better known as an unmanned aircraft. One type of unmanned aircraft that is often used is the Quadcopter. Quadcopters are not only used as a hobby or photography but are also widely used in various other sectors such as plantations, agriculture, and regional mapping. Quadcopters can be used to reach areas that humans cannot reach more quickly. Quadcopters are capable of flying far enough to carry out mapping or area monitoring (Fauzi, A. M. 2019). Monitoring is carried out by utilizing the camera on the Quadcopter which is used to take photos or videos of environmental conditions or areas traversed by air.

In this study the development of a quadcopter aims to facilitate monitoring of forest areas on a regular basis. The working principle of the innovation developed is that the Quadcopter is collaborated with the YOLO (You Only Look Once) artificial intelligence algorithm (Prasanta, M. R., Pranata, M. Y., Firnanda, M. A., & Sendari, S. 2022). YOLO is a smart artificial neural network that is used to detect real-time objects. YOLO works with an algorithm program that has been created by the developer to detect images captured by drone cameras, then maps the images according to the training data that has been input into the YOLO program. By using the YOLO framework, api objects in various conditions can be detected easily by the system. The camera on the drone is integrated with the GUI (Graphic Unit Interface) program on the computer, then the visual data (photos, video) captured by the camera is processed to determine whether the camera detects fire or not.

The function of the drone is to determine and find out the position of hotspots before the blaze grows by sending coordinates if they find a recognized object such as a hotspot, this is done to facilitate and increase the efficiency of monitoring forest areas, to address symptoms of forest fires. In this way, Ministry of Environment and Forestry (KLHK) officials do not need much time to monitor forest areas. Another function of the drone innovation that we have developed is that it can be used to detect humans carrying out illegal logging in forest areas so that when there are people carrying out illegal logging in forest areas it can be immediately identified easily using the help of the Fitsbot drone innovation.

THEORETICAL REVIEW

Peatland Fire Potential

Peatland is land formed from plant material or organic matter that has decayed inundated with water. Plants, especially those from trees, are the main constituents. Peat soils are usually found in wetlands such as swamps, basins, and coastal areas (Manzo-Delgado, L., Franco-Martínez, A., & León-Rojas, G. 2014). Peat is a type of histosol order that is composed of living things or decaying plants with a mineral organic carbon content of 20%. Peat domes on peatlands have sponge-like properties that allow them to retain water and prevent flooding (Wasis, B., Saharjo, B. H., & Waldi, R. D. 2019).

Climate and human activities in managing forests and land are the two main causes of fires. About 99% of people are influenced by climate factors, either consciously or unconsciously. Economic considerations drive human-caused fires (BNPB, 2013). (JICA, 2017). Land conversion up to 34%, illegal cultivation 25%, agriculture 17%, social jealousy 14%, and transmigration program 8% are human-caused forest and land fires in Indonesia (BNPB, 2013).

Drone/UAV

An autonomous aircraft known as a drone that can be flown and loaded remotely using a remote control (Nurkarim, Y. A., Assllia Johar Latifah, & Sayekti Harits Suryawan. 2021). UAVs are drones with automatic control systems that do not require operators (Unmanned Aerial Vehicles). To operate the UAV according to the user's wishes, the UAV can be controlled manually or automatically by processing sensor data. Unmanned aerial vehicles, sometimes known as UAVs, are a rapidly evolving technology with great promise for military and non-military applications. UAVs can be used for a variety of tasks, including surveying, patrolling, finding mines on the ground, conducting research, taking pictures, and more (Perkasa, P., & Aguswan, Y. 2014). The benefit of UAVs can be used on risky missions without endangering pilots.

Image 1. Drone/UAV
(Source: https://exotique.com.mt/product)

YOLO Algorithm

Yolo is a real-time object detection algorithm that uses artificial neural networks to find items in images. The Convolutional Neural Network (CNN) algorithm has been further developed with the Yolo algorithm. When compared to the region-based convolutional neural network (RCNN) approach, the Yolo method enables faster object recognition. This is so that object patterns can be recognized by the Yolo algorithm at a glance without the need for reclassification. The core idea of Yolo is to anticipate bounding boxes by training an end-to-end artificial neural network on the input image, then classifying the object class for each bounding box.

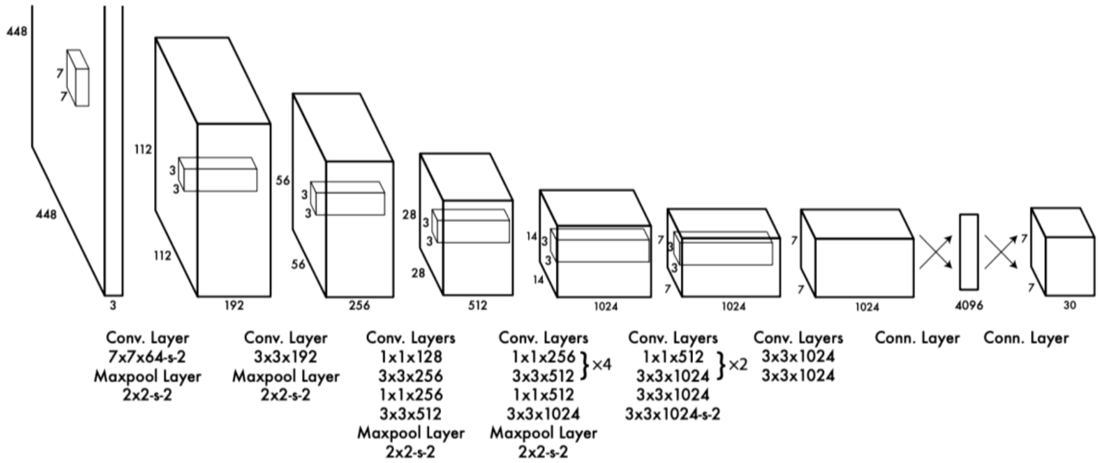

Image 2. Yolo Algorithm
(Source: https://kc.umn.ac.id)

GPS (Global Positioning System)

The United States owns and maintains the GPS (Global Positioning System) satellite navigation and positioning system. This system was created to continuously provide three-dimensional position, velocity, and time information to many users at once, regardless of time or weather, around the world. People around the world today use GPS in a variety of applications that require accurate data on position, speed, acceleration or time. With an accuracy range of a few millimeters (zero order) to tens of meters, GPS can provide position data. To date, GPS is the most well-known and frequently used satellite navigation system on land, sea, air and in space. The field of application of GPS extends beyond the military.

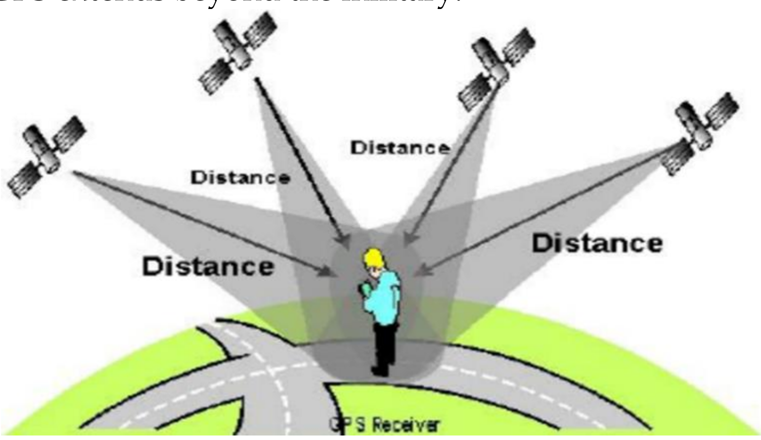

Image 3. GPS (Global Positioning System)
(Source: https://www.researchgate.net)

METHODOLOGY

The method used in implementing this program is Research and Development (R&D) which is a research method to produce a new product that can be accounted for. This R&D research went through several stages following the ADDIE development model consisting of analysis, design, development, implementation, testing, and evaluation.

Analysis Stage

The first stage is to identify the problem that the author obtained through observation and strengthen it with secondary data obtained using the method of literature study. Literature study is a data collection technique by searching and reading scientific literature that has existed before and is used as a reference. Data is obtained from various credible sources such as scientific journals, books listed in reference sources or bibliography.

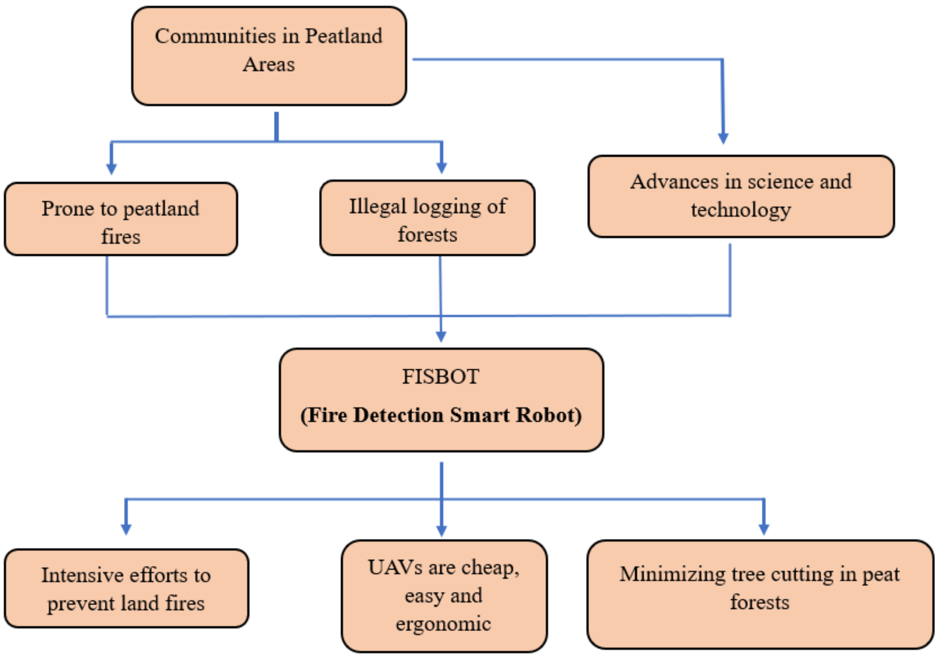

Image 4. Framework of thinking
(Source: Personal analysis)

Hardware Design Stage

The second stage is the design of the FITSBOT, starting from identifying the components and geometric shapes of the tools, materials, joints, and maximum loading using analytical simulations. Electronic hardware design was made using ISIS Proteus software and using Autodesk Inventor to design the tool framework. Hardware is made according to the needs and functions. The FITSBOT body uses composite materials. The design process for this tool must be carried out carefully to obtain ideal results with an ergonomic design.

Image 5. 3D Design
(Source: Personal Design)

Software Design Stage

Software is created using the Visual Studio Code application with C programming language. Software development is carried out by logical problem-solving steps (algorithms / flowcharts), then resolved in the form of program syntax.

The software is designed based on a GUI (Graphic User Interface) so that it allows the user or users to easily interact with a computer device used by the user. Users who access can monitor the condition of the area being monitored as well as the condition of FITSBOT at a time and place flexibly anytime and anywhere.

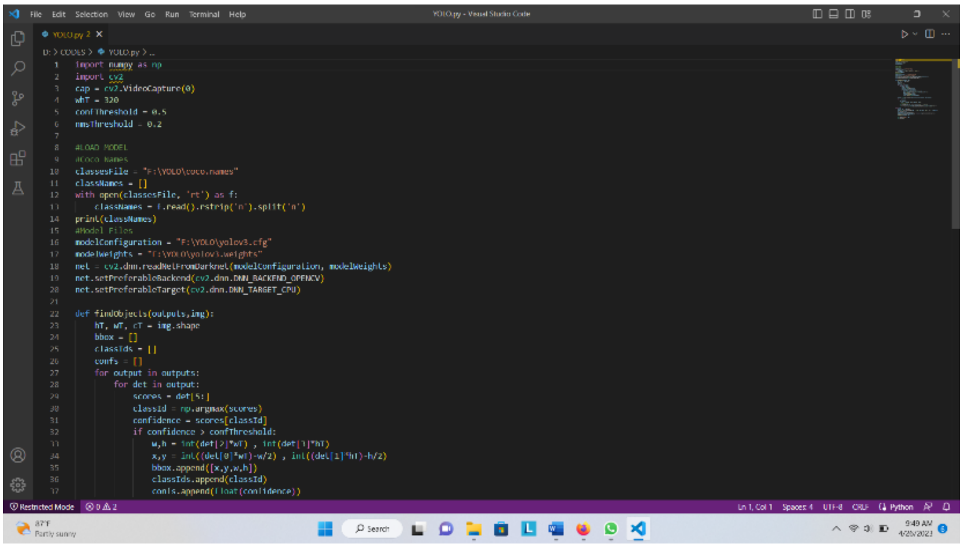

Image 6. Software Design
(Source: Personal Design)

Manufacturing Stage

At the manufacturing stage, the circuit that has been made in the PCB design is made in real form. There are two steps for making a FITSBOT, namely the step for making an electronic device and the step for making a frame. Steps for making an electronic device: (1) The design is printed on glossy paper and then printed on plain PCB. (2) The PCB which contains the circuit is dissolved in FeCl. (3) Cleaning circuit and drilling. (4) Installation of components. (5) Hardware programming.

The steps for making the body and framework are: (1) Design the framework or working drawings using the Autodesk Inventor application. (2) Cutting carbon fiber and aircraft frame according to the size on the working drawings. Combining the chassis and electronic circuits to be combined into an quadcopter.

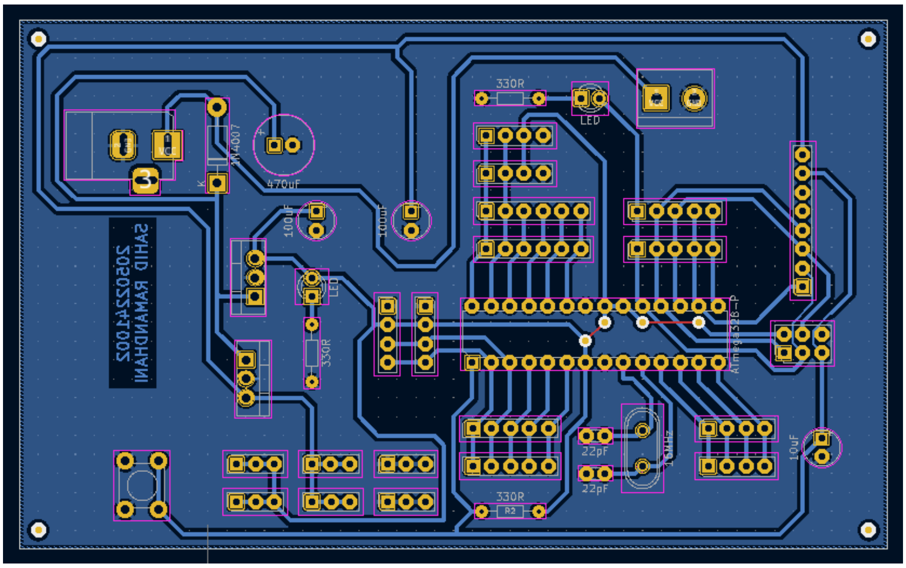

Image 7. Controller Design
(Source: Personal Design)

Testing Stage

This stage is carried out based on the FITSBOT function as a robot for monitoring forest or peatland areas. The testing phase was carried out in the Yogyakarta State University area. This test was carried out to test the robot's endurance, cruising range, robot's resistance to wind, the camera's ability to monitor, and the flying robot's ability to release a fire extinguisher. The FITSBOT system will be controlled manually with a remote control or automatically via an autopilot system.

Evaluation Stage

The purpose of evaluation is to determine the suitability of plans and realization. So that if there are deficiencies it can be corrected while if the implementation is right it can be maintained and developed.

RESULTS

Technology Concept (Fire Detection Smart Robot)

A quadcopter is a type of drone or unmanned vehicle which has four motors equipped with four propellers on each motor which are used for flying and maneuvering. Each rotor, namely the propeller and the driving motor, has the same distance from the center of mass of the vehicle. Each rotor generates lift, with each rotor one-quarter greater than the overall mass, enabling the quadcopter to fly. The speed of the quadcopter depends on the power of the motor and the weight of the quadcopter itself.

Tool Work System Scenario

The camera detects conditions around peatlands/forests then sends data in real time to the master system, namely the quadcopter. In the case of a prototype that has been made, GPS data is sent in the form of visual data (images or video) which is acquired using a microcontroller processing machine. Data is sent via telemetry with an operational frequency of 915 MHz. The data read by the GPS will be received by the camera attached to the quadcopter. After the GPS sensor data is confirmed to be received, the camera on the quadcopter will capture the location in real time and then send it to the PC/laptop connected to the quadcopter.

After the data is received by the PC / Laptop server, the data will be sent to the server and stored in the database system. This database system can be accessed by operators or parties who have the authority to monitor the area. Apart from being stored, data is also visualized through a GUI (Graphical User Interface) based dashboard application, which is a system/application software used by the user or users to make it easier to interact with a computer device used by the user. Users who access can monitor the condition of the area being monitored as well as the condition of the quadcopter at a time and place flexibly anytime and anywhere.

Calculation Analysis on the Propeller

Stress analysis on the FITSBOT propeller using Anysis Software. Stress analysis is used to measure the deformation of the propeller when the drone is working. By doing this analysis, the designer will know the maximum wind velocity allowed when the drone is working.

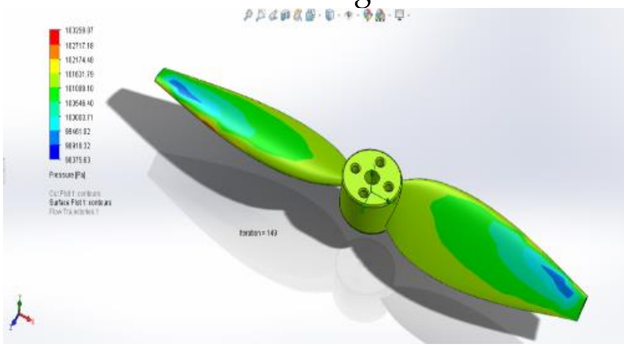

Image 8. Propeller Analysis using Anysis Software
(Source: Personal Analysis)

FISBOT Cruising Power Calculations

Battery Capacity	: 12,000 mAh 120C 4 Cell
Brushless Motors (4)	: @ 1200 KV
Electronic Speed Controller	: 60 A

Table 1. Drones Components

Component	Current (mA)
Microcontroller	65
Compass Sensor	180
Camera	993
Power management	155
Accelerometer Sensor	165
Gyro Sensor	192
Barometer Sensor	136
GPS Sensor	214
	2.100

Calculation of Motor Current and Flying Time
Battery Amp / Drone Amp x 60 Minutes
Motor Current = 3.5 A x 4 = 14 A
Components Current = 2.107 mA

Flying Time Calculation:
= 12,000 mAh / 14.000 mA + 2.100 mA x 60 minutes
= 12 / 16,1 x 60 minutes
= 0.745 x 60 minutes
= 44 minutes

Calculation using Ecalc Software

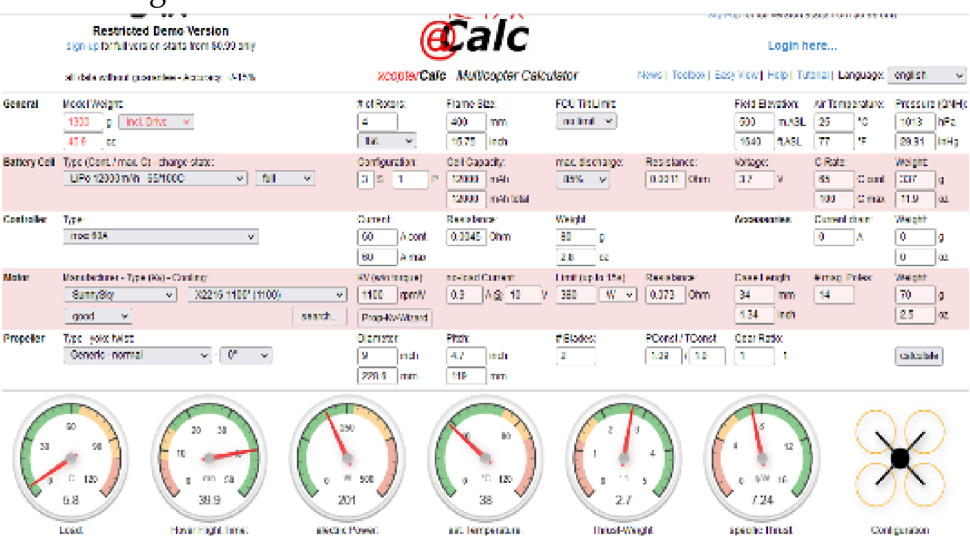

Image 9. Testing using Ecalc Software
(Source: Personal Documentation)

Based on testing using the EcalC software, the following data is obtained:

Table 2. Data is Obtained

Results	Calculations
Drone Maximum Current	5.8 C or 5.8 A/s
Estimated Flight	39.9 Minutes
Electronic Power	201 Watts
Drone Highest Temperature	38° C
Load Lifting Power	2.7 Kg
Thrust	7.24 g/w

FITSBOT Flight Test

Flight test on FITSBOT (Fire Detection Smart Robot) is a test carried out to determine the working quality of a tool. In the FITSBOT performance test, 3 tests were carried out, namely flight and cruising tests, tests carrying fire extinguishers, camera and sensor tests.

Image 10. FISBOT Assembled Results
(Source: Personal Documentation)

Flight test on FITSBOT (Fire Detection Smart Robot) to determine feasibility, function, results and analyze weaknesses in the device. The FITSBOT performance test has several results, namely:

Table 3. Performance Test

Results	Calculations
Maximum Carring Capacity	2.6 Kg
Maximum Speed	60 Km/h
Thrust	7 g/w
Estimated Flight	40 Minutes

DISCUSSION

After several tests of the FITSBOT tool, it was concluded that this FITSBOT tool can monitor land areas effectively and efficiently because it does not require a lot of time and a lot of energy, so that monitoring / monitoring of land areas becomes easier. In addition, this tool can work with manual mode and autopilot mode (automatic) to facilitate users in operating FITSBOT.

CONCLUSIONS AND RECOMMENDATIONS

Drones using YOLO-based artificial intelligence have a fairly high level of accuracy to detect certain objects resulting in very good accuracy. This aims to anticipate object detection errors made by FITSBOT. The YOLO algorithm in this tool is able to detect certain objects such as fire and humans with high accuracy. YOLO-based artificial intelligence works less optimally when land conditions have many obstacles that reduce the visibility of the FITSBOT camera. The VTX (Video Transmitter) system used can work optimally by sending data from the camera to the connected PC/Laptop then the data is processed by the YOLO algorithm and visualized in a GUI-based dashboard application. However, data cannot be captured by the camera when weather conditions are bad which causes limited visibility of the FITSBOT camera.

FURTHER STUDY

Further research needs to be done by utilizing heat detection sensors or others so that data can still be detected by the camera and then sent and received by the PC for further processing. This fire and human detection tool can be developed in the future by using camera technology with heat detection sensors to detect objects that are far enough away so that this tool does not only rely on AI to detect objects.

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