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Design of Video Transmission with Wi-Fi on Runway Inspection using Jetson Nano and Data Synchronization

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ABSTRACT

This study aims to facilitate runway maintenance activities by designing a transmission video on an unmanned aerial vehicle (UAV). This design is designed to transmit video in real time via WiFi and provide location information via the integrated GPS data. The evaluation phase was carried out to evaluate the success of the design according to predetermined criteria. In the trial design, the video transmission distance and data transmission speed were tested, as well as the synchronization between GPS and video data. The test results show that the design of this video transmission has not fulfilled all the criteria set. The design can transmit video and synchronize, but there are problems with Jetson Nano so that it cannot carry out remote trials. It is hoped that this design can assist in runway inspection activities using UAVs, as well as provide accurate information via video and GPS data.

Keywords: transmission video design, unmanned aerial vehicle (UAV), GPS data and video.

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1. INTRODUCTION

The airport is one of the vital facilities that can connect between regions more quickly. With the high traffic that exists at an airport, this facility is required to be in good condition and free from things that can disrupt flight traffic. According to Law No. 1 of 2009 concerning Aviation, Part Two, Aviation Safety Supervision, Article 312 paragraph (2) Aviation safety supervision as referred to in paragraph (1) is an ongoing surveillance activity to see compliance with aviation safety regulations carried out by work units or public service providers which include audits, inspection, observation, and monitoring. Paragraph (3) Supervision as referred to in paragraph (2) is carried out by work units or public service delivery agencies.

Routine inspection and maintenance of the runway is necessary to ensure that it remains in good condition according to the applicable regulations and technical requirements. At airports with high flight frequency, runway checks are carried out every hour or according to established operating standards. The inspection uses a car containing the driver and personnel who inspect visually with direct vision so that it takes time for officers to inspect the runway.

Unmanned Aerial Vehicle (UAV) or commonly known as drones commonly used as an alternative. Drones can also be custom built or can be adapted to the needs of its users. Drones can be deployed to conduct aerial surveys of the runway, offering a bird's-eye view and high-resolution imagery for a comprehensive assessment of its condition. It is hoped that in the future drones can become a solution for the maintenance and inspection of equipment and facilities at airports throughout Indonesia.

Custom-built drones or those adapted to specific needs can be equipped with various sensors and cameras, allowing them to capture detailed images and data during inspection flights. These drones can navigate the entire length of the runway efficiently, covering vast areas in a relatively short time. This not only reduces the workload on ground personnel but also enhances the accuracy and effectiveness of the inspection process.

Incorporating drones into the maintenance and inspection procedures of airports is expected to revolutionize the aviation industry in Indonesia and beyond. With the potential for increased automation

and data analytics, drones can facilitate predictive maintenance, identifying potential issues before they escalate, and ensuring proactive measures are taken.

As technology continues to evolve, drones are likely to play an ever-expanding role in aviation safety and infrastructure maintenance. The integration of these unmanned systems in airports aligns with the goal of fostering a safer and more efficient air transport network throughout Indonesia. As regulations evolve to accommodate drone usage in aviation, airports can leverage these technological advancements to elevate safety standards and optimize maintenance practices, ultimately enhancing the overall flying experience for passengers and flight crews alike.

A. Camera

The Runcam Thumb Pro is a cutting-edge camera that boasts an impressive array of features, making it a top choice for capturing stunning aerial footage. Its standout feature is the 155° wide lens, which provides an expansive field of view, allowing users to capture breathtaking panoramic shots and immersive visuals. This wide lens is perfect for capturing the beauty of landscapes, urban environments, and action-packed scenes with exceptional clarity and detail.

Moreover, the Runcam Thumb Pro offers exceptional resolution options, catering to various filming needs. Whether users require standard high-definition quality at 1080p, ultra-sharp visuals at 1440p, crisp footage at 2.7k, or cinematic clarity at 4k, this camera can be easily adjusted to match specific requirements. This adaptability makes it an excellent choice for a wide range of applications, from professional filmmakers to hobbyists seeking to capture unforgettable moments with unmatched clarity.

The built-in gyro feature is another game-changer for the Runcam Thumb Pro. The gyro function, when utilized in conjunction with the Gyroflow application, ensures that users can capture remarkably stable footage, even during dynamic movements or high-speed action sequences. This gyroscopic stabilization helps eliminate shakes and vibrations, resulting in smoother, more professional-looking footage.

Weighing in at a mere 16 grams, the Runcam Thumb Pro sets a new standard for lightweight, compact cameras in its class. Its low weight makes it an ideal choice for mounting on a variety of platforms, including drones, RC cars, helmets, and other action-oriented gear. This portability and ease of use enable users to take the Runcam Thumb Pro virtually anywhere, ensuring that they never miss out on capturing those extraordinary moments.

Fig 1. Camera

B. WiFi and *Access Point*

WiFi, the popular name for wireless local area networks based on the IEEE 802.11b standard, has become the preferred technology for wireless local area networks in both business and home environments. Although designed primarily for personal applications, WiFi is also used in public places to create hotspots, where users with built-in WiFi features can get broadband internet access. (Paul S. Henry). The access point is used to increase the range of WiFi so that connected devices can access the network in a wider area, so that in this design the UAV can transmit video according to the distance required in the video transmission design.

Lately the bandwidth of WiFi systems has been increased to meet data rate requirements. The latest 802.11 ac WiFi devices can use 80 or 160 MHz bandwidth channels. This allows precise positioning based on time. In particular, a fine timing measurement (FTM) protocol has been specified in the IEEE 802.11-

2016 standard. However, FTM is not yet widely implemented in commercial WiFi devices, nor can it be used to locate the large number of existing WiFI devices. (Shenghong Li, 2019)

Fig 2. WiFi Access Point

Fig 3. WiFi Dongle

C. NVIDIA Jetson Nano

The NVIDIA Jetson Nano, an entry-level board in the NVIDIA Jetson ecosystem, is a small, powerful single-board computer that enables parallel operation of multiple neural networks for applications such as image classification, object detection and more. audio visualization, segmentation, and processing. It has a complete development environment (JetPack SDK) and libraries developed for embedded applications, deep learning, IoT, computer vision, graphics, multimedia, and more. (Ahmet Ali Süzen)

NVIDIA Jetson Nano has a GPU with 128 cores. This resource can be used for AI applications. We can run Pandas, Numpy, Tensorflow, and Keras on a NVIDIA Jetson Nano board. We only focus on how to create AI programs. NVIDIA Jetson Nano will take over your computations. For optimized computation, make sure your program library supports Jetson Nano GPU cores. If you are interested in computer vision, you can apply NVIDIA Jetson Nano to do that. You can connect external cameras via the CSI interface to a USB canera. By installing the OpenCV library, we can use NVIDIA Jetson Nano for creating excellent vision programs by the OpenCV library provides various libraries for video image processing. We can use it directly on your programs like C/C++ and Python. Additionally, OpenCV consists of machine learning libraries facial recognition. (Kurniawan, 2021).

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Fig 4. Jetson Nano

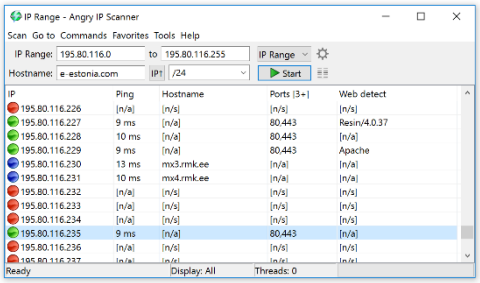
D. Angry IP Scanner

It is an application (software) that is used to scan and search for the IP on the port that is currently active and will provide information regarding that port. Sometimes Angry IP Scanner cannot detect available ports and considers it as a filter. (Emad Ebeid, 2017)

Angry IP Scanner is a versatile application used to scan and search for active IP addresses on a network and provide detailed information about the open ports on each detected device. This software is widely used by network administrators, cybersecurity professionals, and even hobbyists due to its user-friendly interface and efficient scanning capabilities. With its intuitive design, Angry IP Scanner allows users to easily configure the scanning parameters, such as the IP range, timeout settings, and specific ports to be checked. Once the scan is initiated, the application starts probing the specified IP range, looking for active devices and open ports.

Angry IP Scanner was used for collecting information about target system. Angry IP Scanner is a fast and lightweight cross-platform address and port scanner. used to analyze IP addresses in any range, it includes information about one of the ports by simply pinging each IP address to verify it is active, then possibly resolving its name by determining the MAC addresses and vendor. (Brian Cusack, 2017)

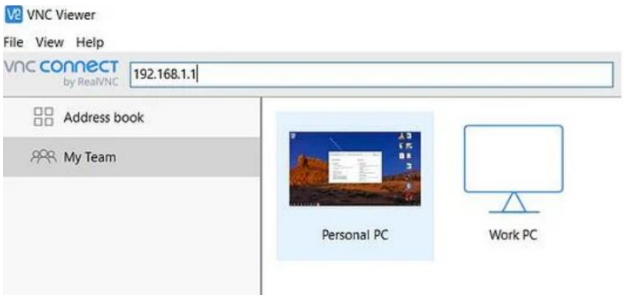
Fig 5. Angry IP Scanner



E. RealVNC Viewer

It is a system that can share a graphical desktop which allows its users to control the desktop remotely from another device and transmit it to have access to control of that desktop. With RealVNC Viewer, users can remotely connect to and take control of a graphical desktop from any compatible device, such as a laptop, smartphone, or tablet, regardless of the operating system. This cross-platform compatibility ensures that users can remotely access and manage their desktops from practically anywhere with an internet connection. As a widely used application in various industries, it has gained popularity among individuals and businesses alike for its ability to enable efficient and secure remote access to desktop environments. (All you need to know about VNC remote access technology, 2002-2022)

Fig 6. RealVNC Viewer



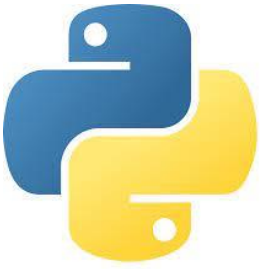
F. Python

Python is currently the fastest growing programming language in the world, thanks to its ease of use, fast learning curve and many high-quality packages for data science and machine learning. But surprisingly, Python is far behind the R programming language when it comes to general statistics and for this reason many scientists still rely heavily on R to perform their statistical analysis. (Pingouin: statistics in Python, 2018)

Python appears in a much wider range of applications such as Internet and website development, database access, desktop GUIs, scientific computation, and software and game development. There are two main Python version series, versions 2.x and 3.x, and both are not fully compatible, they are similar in most parts. Version 2.x is a legacy version, which supports, and maintenance is scheduled to end around 2020. (Jiangang Hao, 2019)

Because it is a scripting language, Python automates tasks that would otherwise have to be done manually. The main difference is that Python programs have to run slower than Java programs, but development takes much less time, according to the Python Software Foundation. although even for C++, Python code is generally one fifth to tenth the length of equivalent C++ code, and "Anecdotal evidence suggests that one Python programmer can finish in two months what two C++ programmers can't complete in a year" the Foundation's website states. (Shein, 2015)

Fig 7. Python



G. RunCam App

Runcam App is an application developed by Runcam, a company that focuses on cameras and accessories for drones, airplanes, and other photography purposes. This application is designed to make it easier for users to control and manage their Runcam cameras via mobile devices such as smartphones or tablets. By using the Runcam App, users can connect wirelessly with compatible Runcam cameras via a WiFi connection. Once connected, users can access camera features and settings remotely via an easy-to-use interface.

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Fig 8. RunCam App

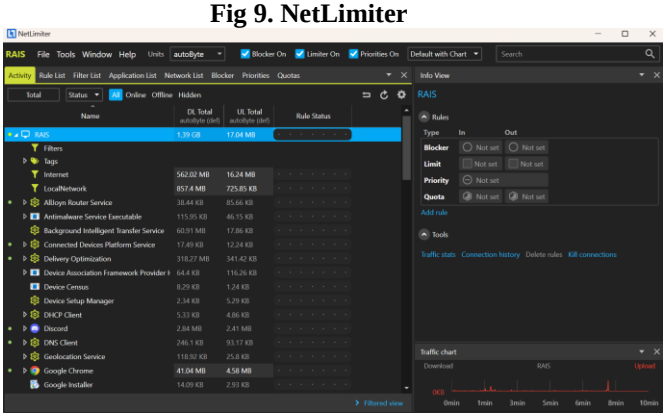
H. NetLimiter

This is an internet traffic control and monitoring tool designed for Windows. It provides full network control over the user's computer. This allows the user to decide where that application is allowed to connect and how fast this connection can be. NetLimiter currently has three versions: one has a freeware monitor, and the other has a paid version, Lite and Pro. (Grace G. Boqueo, 2019)

NetLimiter is an internet traffic monitoring and control application tool for the Microsoft Windows platform. NetLimiter combines various features such as network monitoring, connection blocking, rule editing, and scheduling, marking it as a robust network monitoring application. Most of its features are limited, but for the full version, network throttling features are included. The free version only includes network monitoring. (Hadryan Eddy, 2021)

NetLimiter is versatile software that offers the capability to regulate speed limits for application downloads/uploads or individual connections, as well as monitor internet traffic for internet cafe users. With these predefined limitations, internet cafe administrators can seamlessly manage the bandwidth of your internet connection, acting as a bandwidth shaper or controller. This function empowers users to track the historical internet traffic patterns of users. In summary, NetLimiter is a versatile tool that caters to various aspects of network control, enabling users to monitor, regulate, and manage internet traffic effectively. (Magdalena, 2013)

Fig 9. NetLimiter



2. RESEARCH METHOD

This development study uses the ADDIE method. This method consists of five phases which include analysis and design, development, implementation, and evaluation. In this development research the ADDIE method was used to produce a video transmission design that was designed in stages. (Yeni Marita Juanda, 2022)

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The reason for using the ADDIE development method is because this model has advantages in systematic processing steps. Each phase is evaluated and revised from what was passed, so that the resulting product becomes a product. Moreover, the ADDIE model is very simple, but the implementation is systematic. (Purnamasari)

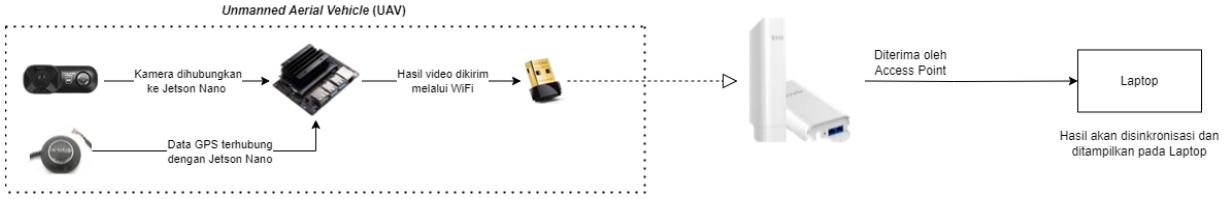
In compiling a video transmission design that will be developed using the ADDIE method which consists of five stages, namely:

- Analysis Phase is the stage of data collection that can be used as material for making products. In this case, the resulting product is a transmission video design. This information is collected in the form of requirements analysis, hardware analysis, and software analysis required to produce the product.
- The design stage is the stage of designing the design that will be built in order to facilitate the design. This design stage includes data collection criteria and flowcharts.
  a. Data collection, in designing video transmission and synchronization with GPS requires a data collection stage in the design. Data requirements consist of material that has been determined at the analysis stage.
  b. Flowchart is a diagram consisting of several symbols that show the steps or flow of a program. The working steps of the system to be made are explained with the help of a flowchart which makes it easy to make video transmission designs.
- Design development is the phase where what has been achieved is implemented in the product design stage. The result of this step is the product to be tested. At this stage product creation is carried out in the form of video delivery designs, GPS data delivery, and GPS and video data synchronization.
- Implementation stage, at this stage the products that have been produced are then implemented. Implementation is carried out on a video transmission design and then it will be tested according to predetermined criteria to find out the results of the design that has been made.
- Evaluation phase, in this phase, evaluation occurs through further development of the design that has been made so that deficiencies in the previous design development process can be identified and resolved in this evaluation process.

A. Overview of the Design System

This design concept aims to implement a video transmission system for runway inspection using an unmanned aerial vehicle (UAV) with a Jetson Nano connected via WiFi. Jetson Nano acts as a GPS and video data processing device to integrate location information in videos and send the results via a WiFi connection to a monitoring device or ground station.

Fig 10. Design System



Currently, equipment such as unmanned aerial vehicle (UAV) is not commonly used, especially in assisting inspections at airports in Indonesia. Using unmanned equipment will help when carrying out maintenance and inspection activities. In addition, the data that has been stored can be processed immediately because it is directly stored on the laptop.

B. Design Stages

The following are some of the activities carried out in the video transmission design process on the UAV.

- The main tasks of the design process consist of WiFi and access point as video sending and receiving. The WiFi dongle is connected to the Jetson Nano, a powerful on-board computing device, which acts as the drone's on-

board computer. Jetson Nano processes the video data captured by camera then transmits it to the ground station the access point connected to a laptop. This configuration provides a stable, high-speed wireless connection for video streaming.

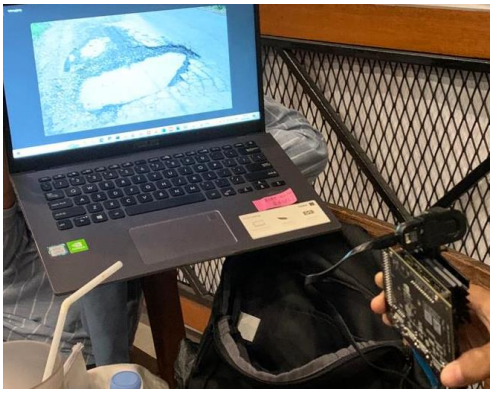
- Camera configuration is another aspect of video transmission design. The camera is equipped with artificial intelligence capabilities, allowing detection and analysis of objects in real time during the UAV. The configuration is carried out using the RunCam App on IOS and Android platforms. After configuration, the results are encoded in form if code accessible by the Jetson Nano. This approach streamlines the data transfer process and facilitates efficient communication between the camera and the on-board computer.
- Sending GPS data to Jetson Nano. This delivery aims to synchronize which can find out the coordinates of the objects detected by AI. Synchronization is generated from the detection results of Jetson Nano with the coordinate points obtained on the GPS. The data for the GPS module will be retrieved by Jetson Nano using Ardupilot. The GPS data can be retrieved through the Mission Planner application, then the GPS data will be sent via MavLink.
- These tests evaluate various critical parameters, such as data transmission distance to assess maximum range of reliable communication, data transmission speed to measure transfer efficiency of data and synchronization between GPS and data video for the alignment of detected objects with their real coordinates.

3. RESULTS AND DISCUSSION

After the design is done, the next stage is the design trial. This trial will evaluate whether the design can work according to the specified criteria. The following are the steps in carrying out a design trial.

- Conducting trials locally, carrying out trials by connecting the jetson nano with WiFi via an Ethernet cable. Local trial results can send videos in real time but there is still a lag in sending videos.

Fig 11. Local Test



- Test video sending. The video will be sent via WiFi from the UAV and then the video will be displayed on the laptop. In the video transmission experiment that was carried out locally using a sample photo of a pothole on the road, the video that has been processed on the Jetson Nano can be sent via an access point and dongle and can be displayed on a laptop. Local trials were conducted to determine the bandwidth needed to transmit video. Checks are carried out using the Netlimiter application, where bandwidth will be regulated to determine the required bandwidth capacity. The check is carried out with several settings, namely as follows:

Table 1. High Video Quality

1080p@60FPS	
Speed	Delay
500 Kb/s	9.3 Second
10 Mb /s	8.8 Second
15 Mb /s	8.5 Second

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Table 2. Medium Video Quality

1080p@60FPS	
Speed	*Delay*
500 Kb/s	8.3 Second
10 Mb /s	7.7 Second
15 Mb /s	7.3 Second

Table 3. Low Video Quality

1080p@60FPS	
Speed	*Delay*
500 Kb/s	7.6 Second
10 Mb /s	7.1 Second
15 Mb /s	6.9 Second

- Perfomed a video sending test with 540 meters, this distance was obtained because there are obstacles in the tested area such as trees, buildings, and tower. At this distance WiFi can still be received by smartphones and when the speed test is it gets 4.45 Mbps for downloads and 15.64 for uploads. However, there exist a hurdle where the Jetson Nano cannot display video on the laptop (as a ground station).

Fig. 12 Distance

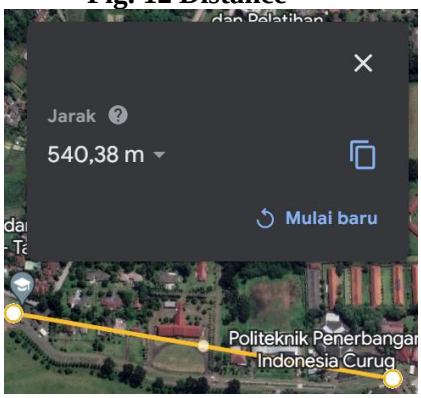
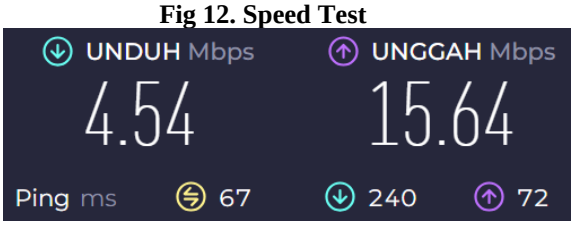


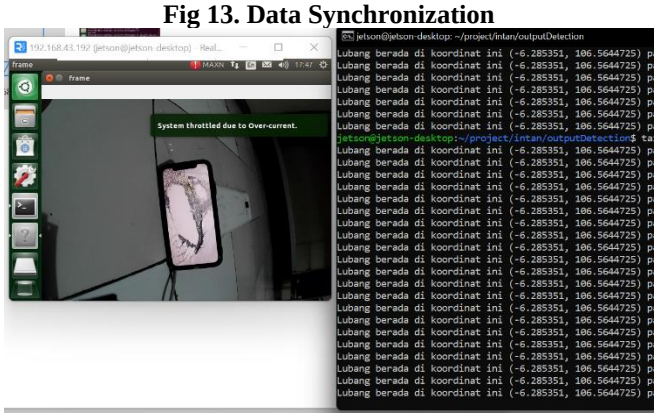
Fig 12. Speed Test



- Once the GPS and Jetson Nano modules are connected and configured, the next step is to synchronize the GPS data with the video processing time on the Jetson Nano when the UAV is at a specific coordinate point. The GPS data received from Mission Planner is still in NMEA format and needs to

be reprocessed and sorted to obtain relevant information. Once the data has been parsed, it will be combined on the jetson nano using the pynmea2 library for the NMEA protocol.

Fig 13. Data Synchronization



4. CONCLUSION

Based on the results of the overall design and testing of the video transmission design on runway inspection using an unmanned aerial vehicle (UAV) and synchronization of GPS and video data, there are several obstacles so that the following conclusions can be drawn:

- In this design video transmission can send video results in real time which is done by using WiFi as a video transmission medium.
- The video transmission design has not been able to transmit video within 1800 meters.
- The transmission video design can display the synchronization results between GPS data and video on Jetson Nano.

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