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Enhancement of Existing Virtual Air Traffic Control Systems

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Abstract:- Airports face financial constraints in the use of Air Traffic Services (ATS) provided by the conventional tower. The Virtual Air Traffic Control Tower is anticipated to be an economical and safe alternative for a conventional tower. The enhancement of the prevailing Remote Virtual Tower System comes with a challenge of improving the efficiency of Air Traffic Control Systems in terms of safety and security. This article describes the various enhancements that can be implemented in remote tower systems and airports to enable effective ATS. The modifications are incorporated to the pan tilt zoom (PTZ) camera systems to offer improvised visibility and target tracking technology thereby identifying unauthorized surface movements, engine heat, leakages, wildlife on an airfield and produce anomaly warning signals helping to mitigate risks before accidents. It also helps in reducing the time taken for these operations, if done manually. The implementation of an Extended Reality (XR) system and additional features considering the cost saving aspects will increase the productivity of control work. Suggestions are also made to upgrade the current software such that the overall performance of ATS will increase. These changes can help the controllers to detect early signs of performance and deploy predictive maintenance accordingly.

Keywords:- *Virtual Air Traffic Tower, PTZ cameras, Air Traffic Control, Extended Reality, Airport Operations.*

I. INTRODUCTION

Air traffic services (ATS) are services that facilitate the safe, secure, and well-organized movement of aircraft, by regulating as well as assisting air traffic in real-time. Organized ATS has been an important part of aviation since at least the late 1930s. Significant improvement in digital technology offers an opportunity to change how ATS is conducted. The conventional tower configuration of ATS is to have air traffic controllers physically present at towers located in the airport and perform operations by directly looking out-of-the-window (OTW). Challenging this conventional tower setting is a solution that has been brought forth in recent years – the Virtual Air Traffic Control Systems (VATCS)[1].

The basic concept of VATCS is to supply ATS to one or multiple airports by providing services like communication, navigation, and surveillance from a remote location. This is anticipated to provide improved service capabilities, reduced costs, and improved safety and security at airports compared to conventional solutions. Although in certain aspects VATCS outperforms conventional ATS, there are various socio-technical related obstacles, making it challenging for VATCS to replace conventional ATS. Inadequate awareness of these obstacles would potentially impede the competitiveness of VATCS technology in general and VATCS providers in particular. The purpose of this study is to gain an understanding of how modifications can be done to improve the existing quality of VATCS.

The article describes various techniques that can be implemented in the Remote Tower Systems that improve its efficiency and reduces the probability of accidents. The basic technical requirements for the Remote Tower concept are high-resolution cameras (PTZ camera) installation at various locations in the local airport. A challenging problem that arises in such a setup is the replacement of the out-of-the-window (OTW) view of the tower with a virtual screen. To get a clear vision of the airport it is important to mount the cameras on the mast at an appropriate height. The paper targets to provide better quality software that would improve the screen pixelation and resolutions in the camera.

Advancing the camera systems with an anomalous warning system so that the camera can recognize any unauthorized surface movements and send warnings to the Air Traffic Controller helping to reduce the pressure on the Air Traffic Controller. These technologies will help in saving time and reduce the probability of accidents. Upgrade the camera to detect virtual parking lines and active crossing. When the aircraft is sent for maintenance it takes a lot of time to determine the temperature and inspect any fuel leakage.

A possible solution to the problem at hand is to empower the cameras with sensors that could sense the heat and fuel leakages in any part of the aircraft. By applying this technique the maintenance cost incurred and the time consumed is reduced. Implementation of Extended Reality systems and other additional features will help in increasing the productivity of the control services. Another improvisation that can be provided is giving the cameras the capability to get the whole vision of the airport from a distance of about fifteen miles when the aircraft is approaching the runway. Enhancing the technology such that the controller gets the ease of giving guidance to a particular aircraft at any airport with just one click will reduce the

probability of hazards. The study aims at providing solutions to various problems that would help the airports to opt for a virtual remote tower over a conventional tower as a dominant solution for ATS.

II. PROPOSED METHODOLOGY

The approach for enhancing the existing technical requirements of VATCS comes with a lot of challenges. VATCS is a concept that faces technical and non-technical challenges for its successful implementation as it will affect the technology providers, air traffic controllers, pilots, and airports. This study aims to gain the perspectives of all of them..

The overall task is divided into three major divisions:
(i) Identifying the various problems affecting the VATCS and defining the area of its effect.
(ii) Identifying the causes of the listed problems.
(iii) Verification of the compatibility of the solution designed.

The first step involves the identification of the various problems affecting the VATCS and how they affect the quality and the system.[2] After listing out the problems we start finding out the cause of the problems and provide suitable solutions for the same. The solution cannot be approved until it is verified. After the verification process, the best solution is finalized.

III. CAMERA SYSTEMS

The implementation of Virtual Air Traffic Control System comes with a threat of designing meticulous visualization systems in the remote towers, as visualization plays a vital role in this sphere. Therefore, it is significantly necessary to ensure the proper working of the cameras at all stages. The following are the various factors that are to be considered for designing efficient video information systems, the necessary enhancements that can be made are listed below.

A. Camera Positioning

In the case of Virtual Air Traffic Control Tower, the most important component is the PTZ cameras. The visibility and area coverage are the factors that depict the ease of the Air traffic controller. It was found that mounting the camera on a pole of height 1000 feet will give a 37 degrees field of view that can give a better view of the airport such that the pole is placed at a minimum distance of 400 meters from the runway. [3]

B. Interference of Magnetic Flux

There is a presence of magnetic flux inside the battery of the cameras. This problem can be overcome by magnetic shielding. Magnetic shielding involves the steel or copper plates placed in the walls. The purpose of these plates is to capture the magnetic field based on the geometric make-up. It results in the calculation of the blockage of the magnetic field.

C. Quality of PTZ

The quality of the PTZ cameras can be enhanced by incorporating optical zoom features into existing systems. The optical zoom feature physically adjusts the camera lens, changing the focal length to zoom in and zoom out as required, and thus maintaining better image quality.[4] Thus, this feature helps in obtaining even a minuscule view of the image being monitored without any quality loss, thereby Also, the quality can be further improved by upgrading the cameras with advanced high-definition technology. 8K Ultra-High-Definition (UHD) (7680 × 4320) is the highest resolution available. 7680 × 4320 has 33.2 million pixels which is double the resolution of 4K UHD in each dimension. [5]

D. Capturing engine heat, fuel/fluid leakage

Detection of fuel or fluid leakage is one of the most tedious tasks of the maintenance crew. Thermal imaging cameras can be used to detect unnecessary fuel leakage that helps in saving time and maintenance costs. Since the cameras do not require light they are not affected by any change in the weather. These cameras have the capability of sensing the leakage from a distance of 50km. Incorporating the cameras with proper alarms to alert the crew about the fuel leakage will help in better and easy detection of fuel or fluid leakage.

E. Operation during rain and fog

Operating the cameras during poor weather conditions becomes challenging as fog and rain can severely limit the range of a thermal imaging system due to scattering of light off droplets of water. Thus, to overcome the scattering of light, an optimum temperature difference is to be maintained. This can be achieved by housing a thermal shield above the camera along with a sensor that detects a drop in temperature and automatically regulates the temperature by heating the vicinity to a specified temperature thereby giving a clear image even in poor weather conditions. A novel imaging system can be used to overcome this problem. This system uses a different technology that can gauge the distance of objects shrouded by fog thereby giving a clear image even in poor weather conditions. The imaging is done in four simple steps: (a) Time profile estimation, (b) Background Estimation, (c) Signal Estimation, (d) Scene Reconstruction. The target parameters-Reflectance Estimation and Depth Estimation is later found out by following the above mentioned four steps.[6]

IV. COMMUNICATION BETWEEN AIRCRAFT AND AIRPORT

Effective communication is the fulcrum of the Air Traffic Control System and an important aspect of aviation safety, without which commercial aviation can become dangerous. Poor communications have contributed to several deadly planes crashes since the beginning of modern air travel. Thus, to ameliorate the communication between the airplane and airport, a visual guide can be presented in the cockpit which provides the pilot with a clear vision of the airfield.The visual guide consists of the view of the location

where the aircraft is heading during landing and takeoff at about 15 miles from/to the airport.

V. DISCUSSION

Virtual Air Traffic Control of airports implies the use of cameras as a direct replacement of direct visual observation or Out-of-the-window (OTW) view from the airport control towers. The concept of Virtual Air traffic control will have a wide scope in the future as it is accompanied by a lot of benefits especially for smaller airports and is also cost-effective.

This study was performed to investigate the various problems encountered by the Virtual Air Traffic Control Systems under various conditions. One of the major requirements for the efficient functioning of Virtual Air Traffic Services is the PTZ Cameras. A list of problems was identified after a thorough study on the existing Camera systems, keeping in mind the cost-effectiveness of a few problems. Our analysis leads to the definition of a shortlist of possible solutions to the problems faced by PTZ cameras. A few of the major problems faced by the Air Traffic Services to switch to a Virtual Traffic Control System are the right positioning of the cameras, resolution of the cameras, visibility in poor weather conditions, etc. The cost reduction in the Aircraft maintenance sector is also addressed by providing cameras that can detect engine heat and fluid leakage. The objective of this research work is to understand the limitations of the camera systems and improve the existing condition of Virtual Air Control Systems.

VI. CONCLUSIONS

The study focuses on the betterment of the existing Virtual Air Traffic Control Systems. It involves the improvement of the existing technical requirements to provide a better view of the airport and also augmenting the communication between air traffic controllers and pilots by implementing suitable latest technologies available to deliver efficient air traffic services from a remote tower.

The article presented redefines the various methodologies employed in the operation of Virtual Air traffic Control Systems. The study covers different enhancements that can necessarily be implemented into the existing systems for their efficient and secure functioning. Our main focus is on the improvements in the fundamental component of the VATCS which is an efficient visualization System, as the whole operation of the air traffic control system is solely dependent on it. Since one of the main aspects of Remote Virtual Tower is to achieve multiple/simultaneous configuration that is controlling multiple airports from a single tower, the study is conducted on the major challenges that may be encountered in various operating scenarios. The probable complexities that may be faced by the controllers are also identified. Suggestions are made to incorporate all the advanced technologies into one system such that it addresses all the problems encountered during critical conditions thus making the control process easy for the air traffic controllers. Also, the communication between the aircraft and the controller is enhanced by introducing video-based control for air traffic management services in safety-critical environments. Standardized RVT that enhances the ATS levels and the level of flexibility for airports to improve their air traffic management and profitability has been proposed.

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