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"Auto-Pilot System with Crosswind Landing"

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Abstract

An Intelligent autopilot system can perform different types of tasks like basic flight manoeuvres after take-off point A to point B but cannot perform landing and take-off and emergencies, here in this research we introduced an algorithm that can handle at least one emergency of crosswind landing with the help of *machine learning* so that will help it to store data of every emergency landing in the dataset and further this will be used to perform automated crosswind landing. All the collected data from the *dataset* will be handled by *FD* (Flight Director) using *ANN* (Artificial Neural Network) algorithm the autopilot system will perform desired actions on the current situation with the help of all sensors data i.e. *LA Sensor* (additional sensor), *Pressure Sensor, Temperature Sensor, Radar, Speed Sensor, Position and Displacement Sensor, GPS* (Global Positioning System).

Keywords: **Machine Learning, FD, ANN, LA Sensor, Temperature Sensor, Radar, Speed Sensor, Position and Displacement Sensor, GPS**

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1. Introduction

In the Existing scenario in an emergency, the human pilots have to take control from the autopilot system and they are trained to handle these emergencies i.e. turbulence, crosswind landing/take-off, emergency water landing, landing without gears.

We are particularly dealing with emergencies that take place during the crosswind landing. To encounter this problem we come up with an Algorithm.

The Algorithm works on the basics of the existing autopilot system, taking necessary information from the flight director and using it for the algorithm as Defined in the flowchart, with this process the autopilot can perform the exact manoeuvres necessary to land the aircraft in the crosswind scenario.

This paper is structured as follows:

Part (II) covers the background which includes wind effects on autonomous flying and cross landing.

Part (III) The data collection, storing of data and using ANN to make decisions on collected data is explained.

Part (IV) describes the approach runway lights for aircraft.

Part (V) describes the overall algorithm for autopilot crosswind landing.

Part (VI) Provides conclusions and future work.

2. Background

A. Wind Effects on Autonomous Flying Aircrafts

When combined with the navigation systems' cumulative flaws, maintaining a desired flight route or course becomes a significant difficulty. The physical characteristics of the Vehicle Dynamic Model (VDM) are used to explore the impact of wind on navigation systems in addition to the control inputs within the navigation filter's algorithm. A method for coping with strong wind effects during flights is proposed in, which entails assessing wind impacts that are both steady and powerful in nature and designing a manoeuvring strategy to deal with them.

B. Crosswind Landing

During an approach, two techniques are used to deal with crosswind. The first is called Crabbing, and it entails creating a specific amount of drift or crab in order to adapt the aircraft's nose to the direction of the wind. The second method, known as Wing-down, entails creating a constant sideslip to resist the crosswind's drift. In fact, throughout the approach phase, it's common to mix the two approaches to varied degrees. Figure 1 illustrates the hazard zone for landing in a crosswind.

Use the crab technique to fly final approach crabbing against the wind to prevent drifting left or right of centerline. You hold the crab all the way to the flare, then use the rudder to align your nose with the runway and the ailerons to avoid drifting in the wind immediately before touchdown. Although the crab technique can be a straightforward way to retain centerline on final approach, "kicking out" the crab right before touchdown requires a great deal of judgement and time [11].

In most cases, landing in a light aircraft with the wing low method is a better way to achieve a smooth crosswind landing. When flying the wing-low method, you utilise your rudder to align your nose with the runway and your ailerons to control for left/right drift all the way from final approach to touchdown. You're essentially slipping the plane into the crosswind from final to touchdown to keep it lined up with the runway [11].

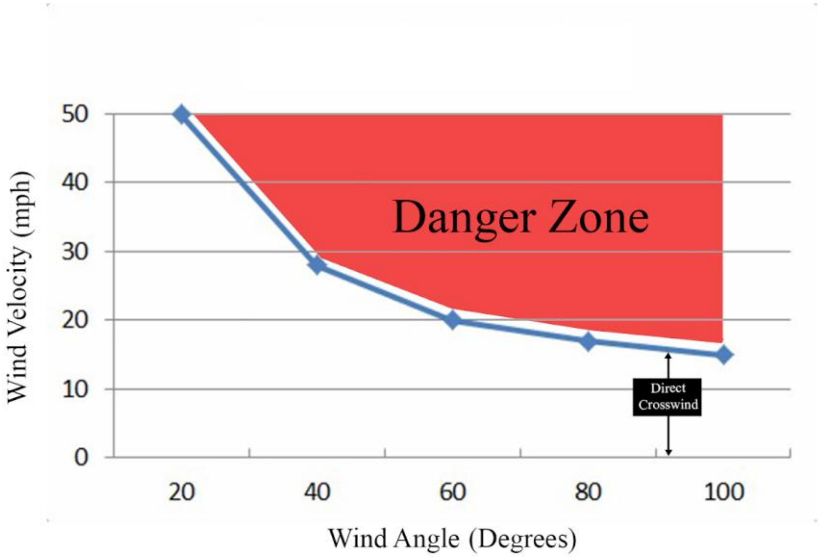

Fig 1. Danger zone for cross wind landing.

3. Approach Runway Lights for aircraft landing

The approach lights on the runway are the first lights the pilot will see throughout the landing process. Unlike other runway lighting, the approach lighting system is positioned in the approach section of the runway and ends at the threshold. The purpose of this approach to runway lighting is to indicate the runway's true direction and allow pilots to see the touchdown zone from afar. The size of the approach light on the runway on instrument runways varies from 2,400 feet to 3000 feet into the approach area for precision. On the other hand, the approach lighting gaps on the non-precision instruments runway cover an area of 1,400 to 1,500 feet. The basic form of approach lighting system has a cross design and usually consists of 17 approach lights that can be seen by the pilot crew even from a distance.

The threshold approach lights, which flash green colour and are part of the approach lighting system, are a unidirectional form of lighting system in the runway that identifies the beginning segment of the touchdown location for the aircraft. While not quite a touchdown position, the approaching lights signify the commencement of the runway's safe landing segment. Three groups of three white lights to the right of the runway centreline lights and three groups of three white lights to the right of the runway centreline lights illuminate the touchdown zone. The touchdown lighting zone originates 100 feet before the runway threshold and extends for 3,000 feet, or the length of the runway [12].

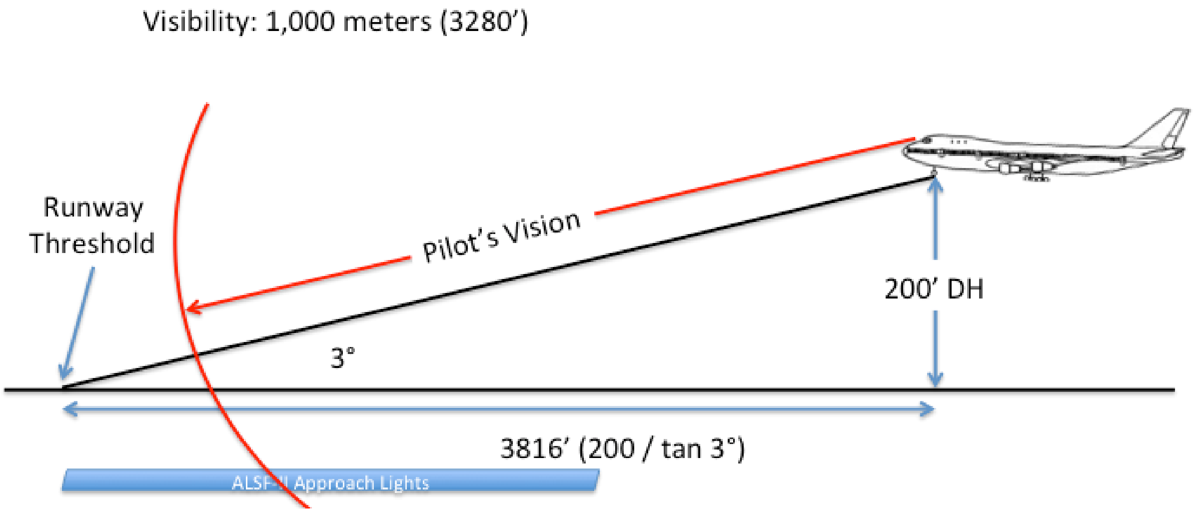

Fig 2. Pilot's Visibility versus Approach Lighting [12].

4. System Architecture

When the proposed autopilot system begins, the process will begin when the aeroplane begins to land. The LA sensor will continuously check the direction and speed of the wind when landing, and if no crosswind is detected, the aeroplane will land normally. If a crosswind is detected, the system will examine all ADC (Air data control) data as well as all sensor data before allowing the flight director to choose between a crab or slide landing and handing over all controls to the autopilot function module to complete the landing. Finally, all of this information will be recorded to a database. The general methodology for this approach is shown in Figure 3.

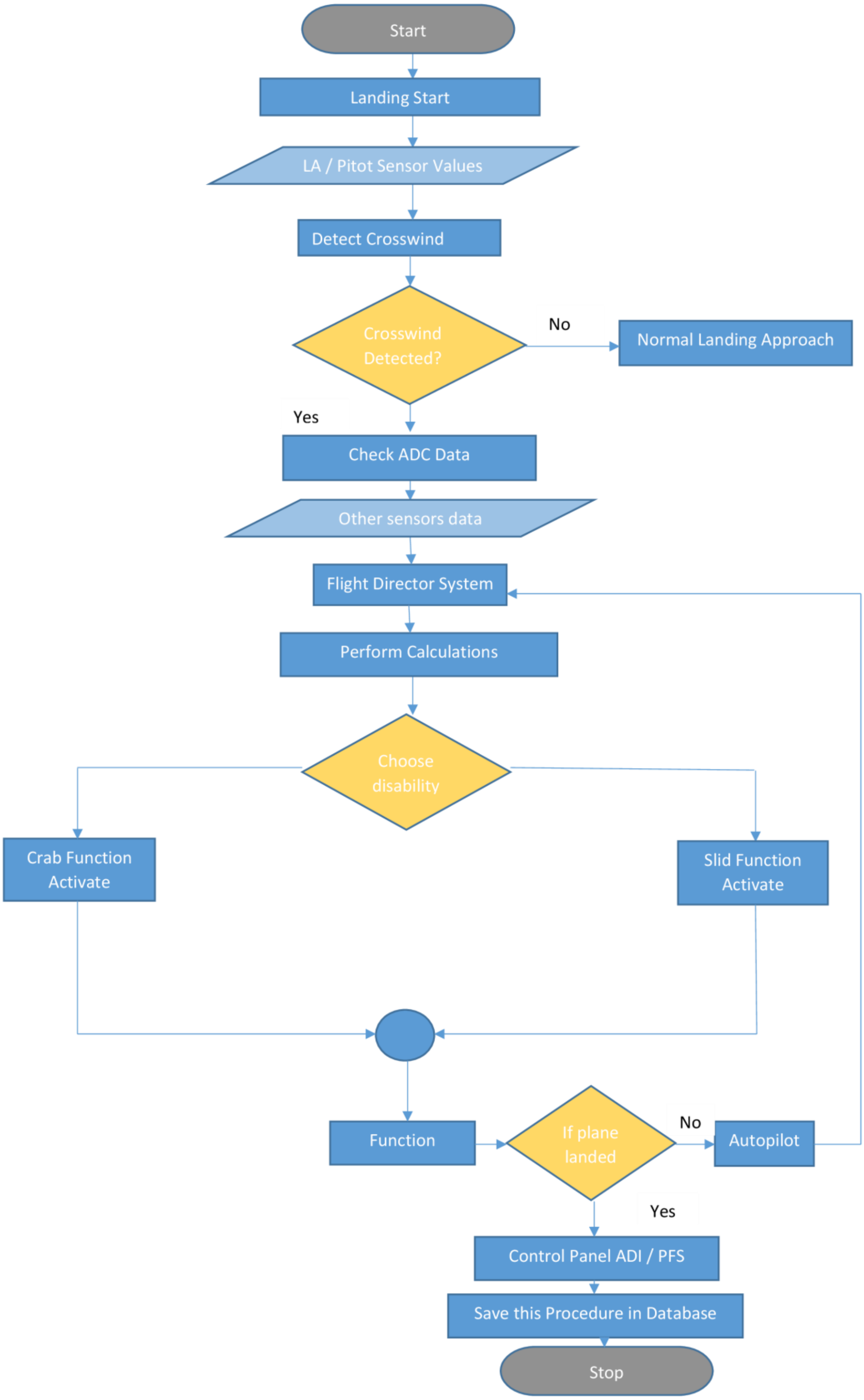

Fig 3. Algorithm for crosswind landing.

Above process will work according to the following steps:

1. **Data collection:**

   The pilot then executes the flying task to be learned using the Interface, which begins immediately prior to the demonstration. The Interface collects flight data from X-Plane via the network through UDP packets, as well as the pilot's actions while performing the task, which are also sent back to the simulator as manual control commands. The IAS Interface converts the simulator's flight data (inputs) and the pilot's actions (outputs) into vectors of inputs and outputs that are sent to the database every one second. The LA sensor's data will be collected here [9].

2. **Data Storage**

   All data from the pilot demonstrator and X-Plane, as well as LA sensor data received from the Interface, is stored in a SQL Server database. Tables in the database are set up to hold continuous flight data as inputs and pilot actions as outputs. The training datasets for these tables are then utilised to train [9].

3. **Artificial Neural Networks of IAS**

   After the human pilot data collection phase is done, Artificial Neural Networks are used to develop learning models from the collected datasets through offline training. Each ANN is designed and programmed to respond to a certain set of commands. The throttle, gear, and brakes values are the outputs of ANN 1, while the speed and altitude data are the inputs. The inputs to ANN 2 are speed, altitude, and pitch, and the output is elevator value. The input to ANN 3 is the roll value, and the output is the aileron value. The input to ANN 4 is the heading value, and the output is the rudder value. During training, the datasets are normalised and retrieved from the database.

4. Conclusion and Future Work

In this study, an innovative and resilient strategy for performing autopilot crosswind landing in the event of an emergency is provided. The aviation industry is currently developing solutions that will reduce the reliance on crewmembers. The goal is to reduce crew members' workload, human error, and stress by designing autopilots that can handle different circumstances without human involvement.

We can design a system in the future that calculates the entire weight of luggage and divides it according to an algorithm so that the weight is distributed evenly in the luggage section of the airplane.

Appendix A

A. We use LA sensor to detect crosswind.

B. Data servers to store all flight data and sensor data.

C. ANN algorithm to construct learning models from the recorded datasets.

D. Approach runway lights during crosswind landing.

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