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Design Of A Neural Network Controller To Enhance The Control Of Flights In Bad Weather Conditions

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ABSTRACT:*Adaptive control is a control method used by a controller which must be adaptable to the controlled system in relation to the parameters which may vary, or are initially uncertain. This is concerned with the control laws changing themselves. The foundation of adaptive control is parameter estimation, which is a branch of system identification. An Artificial Neural Network is used in adaptive control. It is an information processing paradigm inspired by the way the biological nervous systems, such as the brain, process information. This is why its adaptability in flight control processes has continued to attract increasing attention. It is able to answer "what if" questions as required and expected. This has been aptly demonstrated such that to the question, "what if weather is bad?" the answer becomes, "do not land," automatically. Neural Networks as used here demonstrated adaptability in enhancing flight control in bad weather conditions.*

KEYWORDS:*Adaptive Control, Parameter Estimation, Neural Network, Information Processing Paradigm, Flight Control.*

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I. INTRODUCTION

There has been a remarkable increase in activities applying Neural Networks for adaptive control. For clarity, an adaptive control is the control method used by a controller and this must adapt to the controlled system in relation to parameters which may vary, or are initially uncertain. Thus, a flying aircraft appears to have a decreased mass as a result of fuel consumption and this requires a control law that adapts itself to such changing conditions. Adaptive control differs significantly from robust control because it does not have a priori information about the bounds on the ensuing uncertainties or even time-varying parameters. While robust control guarantees that given that changes are within given or defined bounds, the control law needs not be changed, adaptive control is concerned with control laws changing themselves. The foundation of adaptive control is parameter estimation, which is a branch of system identification.

Basically, an Artificial Neural Network (ANN), or Neural Network (NN), for brevity, is described as an information processing paradigm that is inspired by the way the biological nervous systems, such as the brain, process information. This is why its adaptability in flight control processes and designs has continued to attract increasing attention. In this paper, the use of Neural Network controller to enhance the control of flights in bad weather conditions is explored. The flexible use of Neural Networks in deriving meanings from complicated or imprecise data is made of in this presentation. At the end of this paper, it will be seen that it is able to make or provide projections in the event of new situations of interest and hence, answer "what if" questions as required and expected.

Figure 1.0 below shows the application of neural network in flight control system design. As shown, FDIA, which is fault detection, isolation and accommodation, ensures proper and appropriate control analysis of the various functional units responsible for taking decisions during flight. This is done after the neuron has been appropriately trained to take decisions as designed and desired.

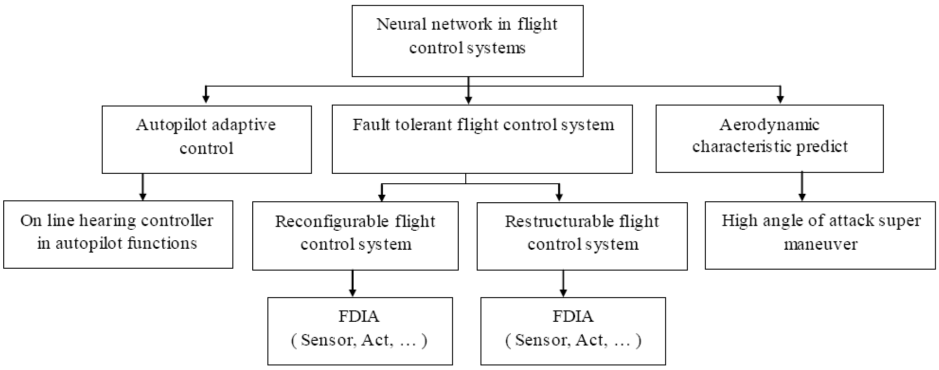

Figure 1.0: Application of neural network in flight control

In figure 1.0 above, a Neural Network sits as a monitor and overseer in flight control systems. When in place, it carries out adaptive control functions on autopilot mode, fault tolerant flight control system, and aerodynamic characteristic predict. When these functions are broken down, a sensor is designated to online hearing controller in autopilot, as both reconfigurable flight control and restructurable flight control systems have sensors designated to themwhile high angle of attack super maneuver also have their own designated sensor. As was mentioned earlier, the FDIA has sensors which ensure that proper and appropriate control analyses are carried out to guarantee accurate decision being taken. Its adaptive property guarantees reliability accordingly.

II. BACKGROUND OF INTELLIGENT FLIGHT CONTROL SYSTEM (IFC).

Intelligent Flight Control (IFC) projects aim at investigating flight control systems that are capable of showing adaptability in the event of failures, uncertainties, and possible system variability. Earlier works investigated control designs that required aerodynamic parameter identification. Subsequently, investigation of architectures that provide Neural Network augmentation to a model inversion controller was carried out. (See Rysdyk&Calise, 1998). This direct adaptive tracking controller integrates feedback linearization theory with both trained and online learning Neural Networks, ensuring that a Lyapunov stability proof guarantees boundedness of the tracking error and possible network weights. The structure that was augmented provided adaptive control without explicit parameter identification, knowledge of the control surface positions, information on nature or extent of the failure, or information on aerodynamic failure or unmodeled parameters. Considering different methods, a conventional direct adaptive method in which the uncertainty is linearly parameterized, is applied. In this approach, to arrive at the linear parameterization, modeling information is employed. Neural Networks, with the ability to approximate a large class of nonlinear functions, provide a feasible and canonical structure for the nonlinear dynamic system representations. Thus, when a mathematical model of a nonlinear plant is available but inaccurate, or when we need to build a system model from experimental data when a theoretical model is unavailable, or impractical, neural networks are powerful tools to enhance applications. Neural network approximated plant dynamics are used in the controller design and synthesis in most neural network control approaches. The stable adaptive neural network nonlinear system control is of particular interest among different forms of neural network based control methodologies. In the stable adaptive neural network control, the self-learning capability of neural networks is enhanced by the robust nonlinear adaptive control theory.

In designing Intelligent Flight Control System, we seek to create a system which could be used in military and civilian aircrafts which is both adaptive and fault tolerant. Specifically, we seek to achieve the following goals:

1. To design and develop a flight control system that can identify aircraft characteristics through the use of neural network technology in order to optimize aircraft performance.
2. To develop a neural network sensor that can train itself to analyze the flight properties of the aircraft.
3. To have the ability to demonstrate the above properties on a modified aircraft during flight, which is the ultimate test bed of the IFCS project.

These goals are achievable. However, in this presentation, the enhancement of flight control in bad weather condition is demonstrated, using neural networks. This will ultimately improve the operation of aircrafts not minding how unfriendly the weather conditions may be.

2.1 New Advances On Improving Aircraft SafetyDuring Flight In Bad Weather Conditions

Engineers in the aviation and aeronautical engineering industry have continued to make advances aimed at ensuring an enhancement in the control of flights in bad weather conditions. Especially very remarkable is the use of Enhanced Vision System (EVS) which has significantly increased aircraft safety under bad weather conditions during flight. This is mainly in airports surrounded with high terrain because the service acceptability level at such airports has the possibility of impacting more favourably. Global Positioning System (GPS) also offers an enhanced operation.

There has been a continued pursuit for improved flight performance with the all-weather arrival and departure (AWARDS) program championed by the European Union. To date, Airbus, Boeing, Bombardier, and Cesna are getting into the market thereby setting the pace for a transatlantic race for EVS dominance which is gaining ground in the improvement of flight control technology. EVS has assisted tremendously in the prevention of controlled flights into terrain (CFIT) and early detection of runway incursions. This is the objective of the neural network controller designed in this research as presented. The overall aim is to efficiently complement the Advanced-Surface Movement Guidance and Control System (A-SMGCS).Both EVS and even Synthetic Vision System (SVS) will enhance the safety and efficiency associated with clear daylight operation to be realized at night and in low visibility conditions and surface operations. EVS can be used to fly GPS based low visibility procedures, using a Head up Display (HUD).

In all, even though an operationally validated SVS has not yet come into commercial use, EVS is a big leap from current situation where pilots only rely on such tools as Instrument Landing Systems (ILSs) or VHF Omni Directional Radio Range (VOR) and Distance Measuring Equipment (DME) for operational safety during takeoffs and landings. It is in line with this development in technology that the neural network presented in this paper was designed. Its development and ultimate application will be another milestone in flight control and safety.

III. METHODOLOGY, DESIGN AND IMPLEMENTATION

To realize the objective of this paper, a combination of MATLAB and VISUAL BASIC software was used to design a neural network controller that enhances the control of flights in bad weather conditions. The result of this design is shown in figure 3.1 below. The design was both by software programming as well as by aesthetic and intuitivedexterity. The explanations given under the design of figure 3.1 below are meant to explain the salient points accordingly.

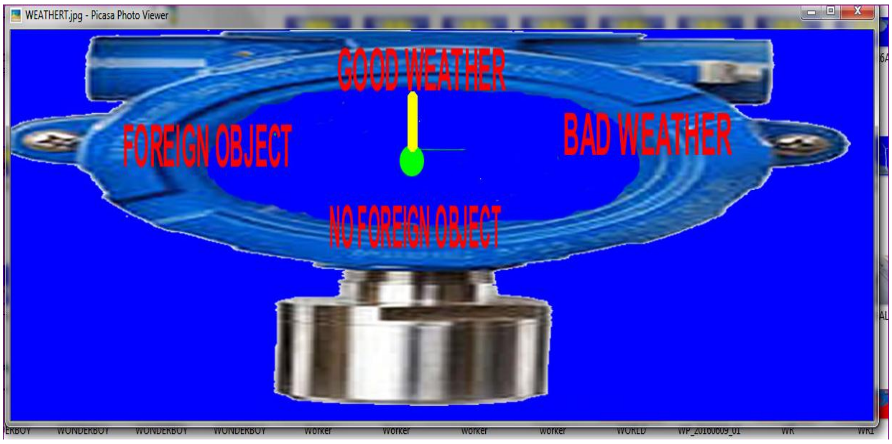

Fig 3.1: Designed neural network controller that enhances the control of flights in bad weather conditions.

Fig 3.1 Shows Designed Neural Network controller that enhances the control of flights in bad weather conditions. In the above figure, the following conditions are shown: Good weather, Bad weather; No foreign object, Foreign object.

The above design is such that the neural controller will appropriately send a signal to the aircraft as to when to land and when not to land depending on the condition on the runway at any point in time. Designated light indicators are appropriately linked to the neural controller to indicate the conditions on the runway accordingly. The detection of the presence or otherwise of foreign objects on the runway is also incorporated in the design as shown. The resulting is an outcome of applying adaptive control in which a controller is made adaptable to parameters which may vary or are initially uncertain. This is concerned with the control laws changing themselves, stemming from parameter estimation which, as has been noted earlier, is a branch of system identification. This way, accident-free landing is ensured.

In figure 3.1, the following conditions are shown in the designed neural network controller:

(i) GOOD WEATHER
(ii) BAD WEATHER
(iii) FOREIGN OBJECT
(iv) NO FOREIGN OBJECT

The design is meant to enhance the successful landing of flights under one ore three of the four conditions as shown. The flow chart for the above conditions is shown in figure 3.2 as follows:

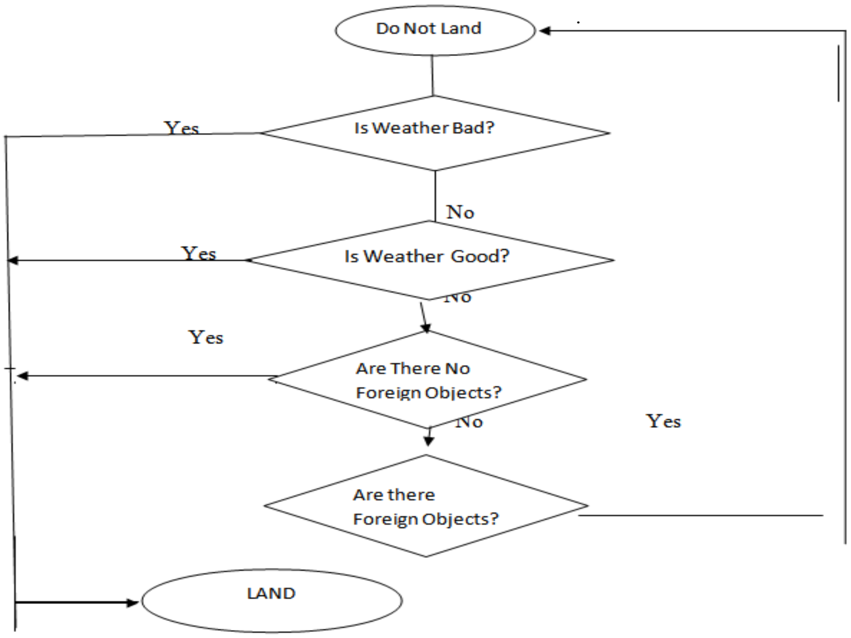

Figure 3.2: Flow chart for flight control enhancement under bad weather conditions.

The flow chart of figure 3.2 is meant to highlight the details of the designed neural network controller design used in this paper. There is an embedded sensor in the neural network sensitive to foreign objects on the runway which provides the only condition under which take-off and landing could not be. The designed neural network falls under the category of Intelligent Flight Control (IFC) system meant to show adaptability in events of failures, uncertainties and possible system variability. The system integrates feedback linearization theory with both trained and online learning Neural Networks. It uses the principle of Enhanced Vision System (EVS) which ensures aircraft safety under bad weather conditions during flight.

IV. SIMULATION RESULT

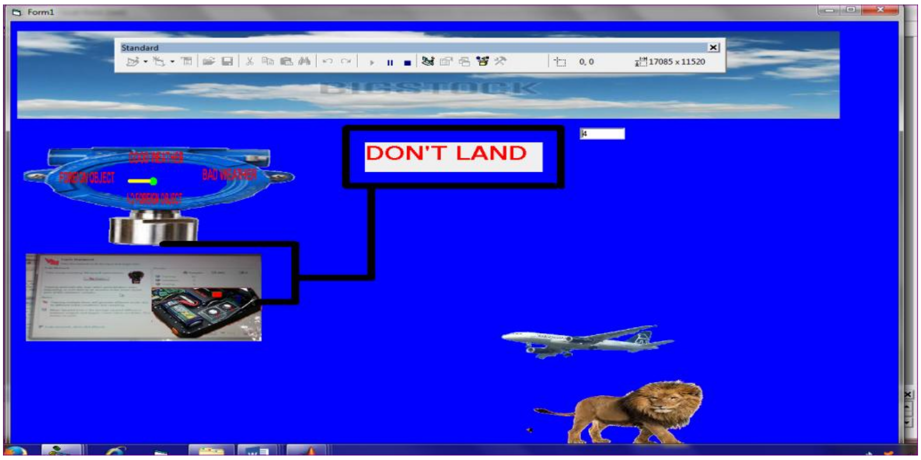

Figure 3.3: The designed simulated Visual Basic aircraft controller showing foreign object on the runway.

When the design of figure 3.1 was simulated using MATLAB, the result was satisfactory as desired as could be seen in figure 3.3. Light indicators showed excellent results capable of sending appropriate signals to the aircraft to obviate accidents during landing. The combination with VISUAL BASIC is particularly innovative as it avails the researcher efficient design specifications and good technology.

V. CONCLUSION

Bad weather conditions are particularly an area of concern to air transportation especially in this tropical part of the world. It has remained a major concern which many scholars in the industry are ever researching to obviate so as to ameliorate the rate of frequent accidents and at the same time, increase the frequency of flights. Implementing the result of this paper will obviously enhance flight control during such accident-prone seasons of the year. As demonstrated here, implementation of this work will save much of human and capital resources and subsequently help grow the economy as well.

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