DEVELOPMENT OF NEURAL NETWORK APPLICATION FOR FUEL CONSUMPTION AND MAPPING FOR AIRCRAFT

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ABSTRACT

The purpose of this paper is to present a simplified method to estimate aircraft fuel consumption using an artificial neural network. The models developed here are can be implemented in fast-time airspace and airfield simulation models. Neural Network Library for Estimation of Aircraft Fuel Consumption basically aims at building an application that uses neural network to estimate the fuel consumption of the aircraft.

Keywords:

FCM (Fuel Consumption Model), AFCM (Aircraft fuel consumption model), FAA (Federal Aviation Administration), AFCM (Advance Fuel Consumption Model), ISA(International standard atmosphere)

1. Introduction

Aircraft fuel consumption is a relevant issue in the planning and analysis of aviation operations in the National Airspace System (NAS). While fuel prices today represent only a fraction (i.e., 16-22%) of the Direct Operating Cost (DOC) of typical aircraft, they still constitute an important expenditure for airlines and general aviation operators. Based on this premise this paper describes a method developed to estimate aircraft fuel consumption using an artificial neural network approach.

2. Present scenario

The existing fuel consumption model utilizes the energy balance relation to estimate the fuel consumption of an aircraft. This relation is based on aerodynamics and engine charateristics of an aircraft [1]. Since the model is basically a combination of different performance fitted curves, the major task in using this model is to determine all the coefficients involved in describing the non-linear behaviour of the aircraft's performance curves. However, the information required to determine these coefficients are usually considered proprietary by most aircraft production companies and cannot be obtained from them. Instead, flight testing and wind tunnel testing are used as sources of information. Unfortunately, the cost of this kind of testing is extremely high.[2] The aim of this project is to use the information directly given from aircraft manufacturer to predict fuel consumption(mapping) of aircraft accurately and efficiently. This information is contained in a handbook known as the "pilot's flight manual".

3. Proposed solution

The proposed neural network approach to aviation fuel consumption application is quite simple in principle. The aircraft fuel consumption data from the flight manual of individual aircraft are presented to the network. The network, by an iterative process, self-organizes and generalizes its own performance data. This process is referred to as "network learning". When sufficient amount of data are

presented to the network, the network will become a "trained network" capable of estimating the performance of aircraft in fuel consumption.

The below figure illustrates the architecture of ACFM

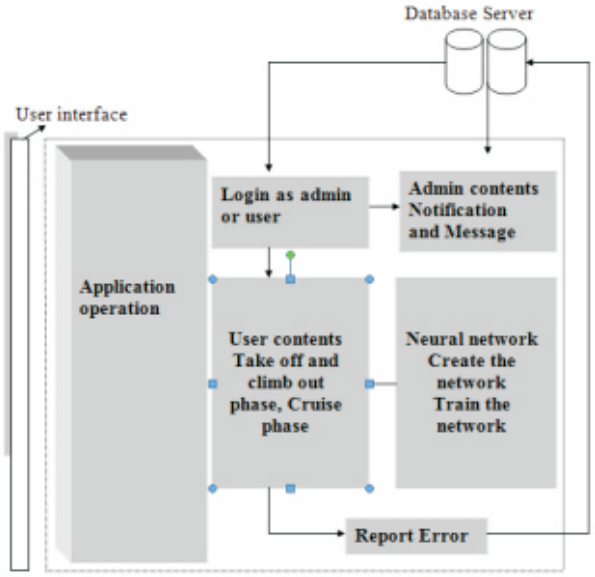

Fig 1: Architecture behind ACFM Applications.

The architecture of the system basically has two logins admin and user. Admin gets user error messages and can keep track of login notifications of the user. The user can calculate the fuel burn rate at take off and climb out phase of the aircraft and at cruise phase. the user can also send error messages to the admin.

4. Implementation

The following features will be implemented

- Fuel consumption Estimation of Aircraft during Take-off and climb out phase
- Fuel consumption Estimation of Aircraft during Cruise phase
- Authentication via login
- Two user types admin and user. Admin capable of receiving the error messages and viewing log of the time at which users login.
- User can send error messages to admin

The application is being implemented using Visual Studio Framework, with SQL database at the back end for storing the data. Encog neural network.dll files are used to obtain functionalities of the neural network. Data definition for the input data is as given below:

Table 1: Data Definition

Data	Data Type	Description
Mass of the aircraft	Double	Initial weight of the aircraft
Mach no	Double	The term is related to velocity(speed of aircraft in a medium/speed of sound)
Temperature	Double	Temperature under which the aircraft flies
Altitude	Double	The altitude at which the aircraft flies

Mass and Mach no are used for fuel consumption calculation at take-off and climb out phase while temperature and altitude are additional variables that are used along with mass and mach no during fuel estimation of cruise phase.

5. Results and Conclusion

The idea of this project was to expand Mr. Schilling's idea to the level that the calculation of fuel consumption need not involve any flight testing or experiments, when similar kind of values are given. This aim was achieved by building the neural network that is capable of predicting the fuel consumed by the aircraft for aircrafts that have similar values as other aircraft values whose values are already known. Thus reducing the cost to a great extent.

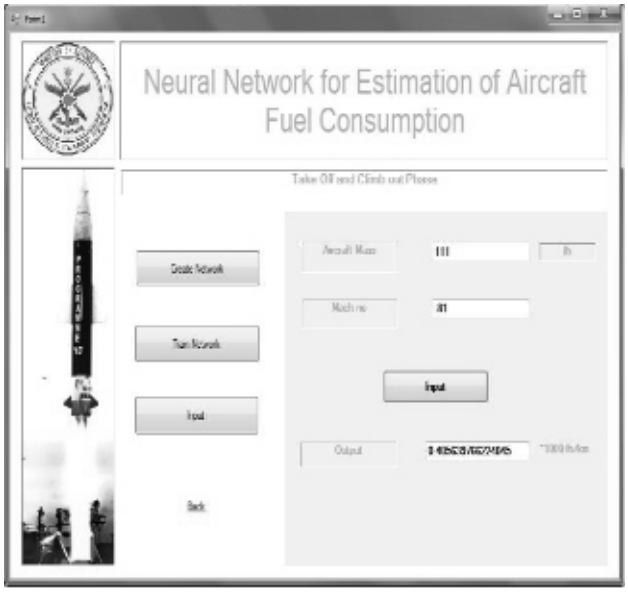

Fig 2: Take off and climb out phase Screen

Figure 2 illustrates the implementation of take-off and climb out phase fuel estimation. It takes 2 variables(mass and mach no) as input values.

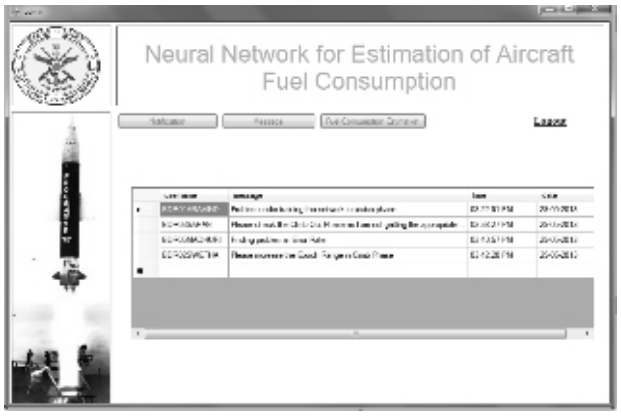

Fig 3: Admin screen

Figure 3 illustrates the implementation of admin screen. the above figure shows the error notifications received by admin.

6. Future enhancements

The following could be the possible future enhancements

- Flight trajectories could be included.
- Automatic sensors could be implemented.
- Graphs could be generated, as interpretation could become easier.
- Generated output could be Stored in external files for further references.

7. References

[1]. McCormick, Barns W. "Aerodynamics, Aeronautics and Flight Mechanics." New York, London: John Wiley and Sons.

[2]. Anderson, John D. Jr., "Introduction To Flight.", McGraw Hill, Inc.