TECHNICAL SUMMARY

AIRCRAFT OPERATIONS CLASSIFICATION SYSTEM

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INTRODUCTION

Accurate counts of aircraft activities are important because the number and types of aircraft practices are related to airport planning and operation. In large airports with control tower operations, one can readily determine aircraft practices because the towers are always manned and logs are kept of all activities. This is not the case at smaller and rural airports that may be manned only during certain hours. Some of the issues involved in deploying technologies for monitoring aircraft operations include: the cost of the monitoring operation, the reliability of the system, the portability of the system, the ability of the system to operate self contained in the field, as well as ability of the system to be acceptable and not interfere with airport operations.

In this project, we consider the development and deployment of systems for measuring aircraft activity at airports. This would include determining the type of aircraft and the type of aircraft activity. The type of aircraft is a basic type such as helicopter, single engine, multiengine, and jet aircraft. The different aircraft activities at airports include takeoffs, landings, touch and go, and low approach. The objective of this project was to investigate the feasibility of developing an automatic aircraft operation monitoring system. This involved investigating candidate technologies and developing a prototype system for monitoring aircraft operations.

OBJECTIVE AND SCOPE

The objective of this project was to investigate the feasibility of developing an automatic aircraft operation monitoring system. This involved investigating and determining technologies, and developing a prototype system for monitoring aircraft operations.

METHODOLOGY

We conducted a technology evaluation and determined that acoustic technology offered the best possibility for developing an aircraft operations monitor suitable for self contained operation at airports. In order to develop algorithms and evaluate the developed system for characterizing aircraft operations, a database of aircraft operations was created. The information contained in the database consists of airport information, runway information, acoustic records, photographic records, a description of the event (take-off, landing) aircraft type, and environmental information. In the application of aircraft counting and classification, we are interested in identifying aircraft from sound signals. This problem may be stated as an object identification problem where the objects are the different types of aircraft. The process of reducing the amount of data while retaining the ability to recognize the object is called feature extraction. The features are represented as vectors and are the input to a classifier.

Sound data are often processed in the root mean square $\boldsymbol{P_{rms}}$ of the sound signal pressure p(t). The term L_p refers to the logarithmic form

$$L_p = 20\log_{10}\left(\frac{p}{p_0}\right)$$

with units of dB or decibels. The equivalent continuous sound level over a specified time interval is the equivalent steady level that would have the same RMS value over that time interval. It is defined as $L_{eq} = 20\log_{10}\left(\frac{p_{rms}}{p_0}\right)$. The L_{eq} acoustic signal has a characteristic shape that is reflective of the different types of aircraft events. One measurement of relevance is the "maximum" value of the acoustic signal. Some sound events such as jet aircrafts are loud. Single engine propeller aircraft landings are very quiet. Other measures can be related to the shape of the curves. A fast aircraft, such as a jet, will have a curve that is steeper as the plane approaches, compared to a propeller aircraft. Other measurements extracted are "skewness" which measures the skewness of the curve and "symmetry" that measures the symmetry of the curve about the maximum value. Frequency measures reflect differences in aircraft. Frequency measures are readily obtained from portable spectral analyzers. The measures we considered are one-third octave frequency measures.

A multi-layer feed-forward neural network was chosen as the classifier. There are three layers in the neural network: an input layer, a hidden layer, and an output layer. The number of input neurons depends on the number of features used in classification. The number of output neurons depends on the number of classes of the aircraft being separated. Four output neurons were used because we considered four kinds of aircraft (helicopter, jet, multi-engine and single engine). We found that the performance is best for a network with a hidden layer with eight neurons.

We had a total of 105 takeoff events for jets, multi-engine, single engine planes, and helicopters. We used 12 of the samples for testing and the rest for training. The training results were 99 percent correct classification. The accuracy of testing was 100 percent classification accuracy.

We conducted another study. This study included 48 sound events that were not aircraft events. Various background sound events such as tractors, cars, trucks, construction sounds, or natural sounds, like thunder, may occur at airports. We collected 48 sound events of vehicles such as cars and trucks for this study. We also implemented a binary tree classification method with a neural network classifier at each node of the tree. We used 153 sound samples consisting of 105 aircraft data and 48 vehicle events. Of these 133 samples were used for training and 20 samples were used for testing. The training results of correct classification were 100 percent. The testing results were also 100 percent.

CONCLUSIONS

We have shown the feasibility of developing an aircraft operations monitoring system. The software we have developed is flexible and can work with any acoustic data collection platform. The primary limitation of the study is a limited data set of aircraft operations.

RECOMMENDATIONS

Our results indicated that the development of a system is feasible. Further tests in the field and refinements to the algorithms and software should be pursued. If these tests are promising one should pursue a commercial solution. A key point is developing relations with a vendor with a commitment to the market. A vendor should be identified and a working relationship established to bring the unit to market.