INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1986

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INTRODUCTION

There were three areas of research sponsored in the Flight Transportation Laboratory at the Massachusetts Institute of Technology under the Joint University Research Program during 1986. The first was the completion of efforts investigating the possibility of using Loran-C for final approach guidance to a runway; the second is a preliminary exploration of the application of automated speech recognition in Air Traffic Control; the third is a continuation of a series of research topics into aircraft icing problems.

1. APPROACH GUIDANCE TO A RUNWAY USING LORAN-C

This work was aimed at exploring the possibility of flying a pseudo-precision approach using an altimeter-aided display system to provide both cross-track and vertical deviations from the approach centerline and glide path. An experimental flight test system was designed for Grumman Tiger aircraft using a King Radio KEAO-346 electric altimeter to provide data on current altitude and a Micrologic ML-3000 Loran-C receiver to provide (x, y, h_o) data relative to the runway touchdown point. (x = longitudinal distance, y = distance from centerline, h_o = nominal glide slope height at x.) An electronic display system was built to give a cross-pointer display to the pilot given continuous inputs from the Loran-C and the altimeter. Several flight tests were flown (at Hanscom Field, Bedford, Mass.), which unfortunately suffered from a number of deficiencies due to tracking dynamics arising from the slow update rate from the current Loran-C receiver. However, approaches were successfully flown, and the feasibility of using the Loran-C data to define the vertical guidance was demonstrated. Comparative data between the ILS guidance and the Loran-C plus altitude guidance was obtained. A complete description of this work is given in Reference 1 of the Annotated Bibliography.

For the second year in a row, an MIT thesis based on Loran-C research won the W.E. Jackson award for "best student thesis" from the Radio Technical Commission for Aeronautics. This year's thesis was written by Norry Dogan, and is available as MIT FTL Report 86-3 (ref. 1).

2. AUTOMATED SPEECH RECOGNITION IN AIR TRAFFIC CONTROL

The basic goal of this work has been to apply existing ASR technology in an ATC environment in order to explore not only some of the potential benefits and problems arising from the practical application of ASR, but also the features and capabilities desirable in an ASR system to be used in ATC (ref. 2).

This basic goal was accomplished by integrating a VOTAN VPC2000 continuous speech recognition system into an existing ATC simulation to provide a means whereby verbal commands issued by controllers and directed towards aircraft could be entered into the computer directly, thereby eliminating the need for blip drivers or pseudo-pilots.

In general, the potential benefits accrued through the use of ASR in an ATC environment involve the simplification of the controller-computer interface in an environment where the primary means of communication is verbal and the use of and reliance on computers is increasing significantly, both in the air and on the ground.

The major difficulties, however, lie predominantly in the handling of errors. In order to address the problem of recognition errors, the syntax for ATC commands was incorporated into a Speech Input Parser in two basic ways. The first utilized a Finite State Machine approach for syntax specification and required active intervention on the part of the user in order to correct any errors once they were detected. The second, however, used a pattern-matching approach to compare the input command to a list of allowable commands in order to determine the best match, and could hypothesize possible corrections if any errors were detected, as long as these did not critically affect the intelligibility of the commanded action.

The user-based techniques developed for correction of recognition errors consisted of utilizing the verbal channel in order to enter specific keywords that would either delete the last recognized word or delete the entire recognized command so far. These were found to be lacking in terms of speed, flexibility and ease of use, and from the fact that errors could even be made in recognizing these keywords.

The automated techniques developed to correct for recognition errors internally were limited by the capabilities of, and information made available by, the VPC system. In many cases, even though they were successful in hypothesizing the location of these errors, there was no capability to reanalyze the data and validate these hypotheses. As such, these automated techniques were more proof of concept vehicles than implementable strategies (at least with the current configuration of the VPC).

The major drawbacks of the VPC system were its sensitivity to variations in articulation (co-articulation, intonation) and its inability to rewind data in order to reexamine sections of speech data. The former is for the most part inherent in the particular recognition algorithm and technique being used and could not readily be changed. The latter, however, is a result of the actual packaging of the software. This problem has been addressed with a new software package (a library of user-callable C-language subroutines to control the recognition functions) recently made available. There are, however, still some limitations in the capability of the VPC that have not been addressed. In particular, the inability to obtain a ranking, including scores, of how well each of the words in the active vocabulary matched the current input, as well as a pointer to the location in the speech data where each of these words ends and the next word would therefore begin.

This research will be continuing in order to develop a highly reliable method of using voice to communicate to an ATC simulation or a future automated ATC system.

3. AIRCRAFT ICING RESEARCH

The aircraft icing effort over the past year has concentrated on utilizing ultrasonic ice accretion measurement techniques in wind tunnel and flight tests to better understand the ice accretion process, particularly in the glaze (wet) ice regime. Application of the ultrasonic techniques has led to previously unrealizable measurements of heat transfer from ice surfaces during accretion. These measurements have identified fundamental differences in the heat transfer and resulting ice growth, between icing wind tunnel and flight icing conditions. These differences appear to be due to relatively high ambient turbulence levels in ground icing test facilities, which tend to increase the convective heat transfer from the icing surface.

An array of ultrasonic transducers has also been flown on the leading edge of a wing cuff mounted on the NASA Icing Research Aircraft (Twin Otter). The ultrasonic array provided a unique record of the temporal and spatial behavior of the ice accretions. This is important to ice accretion modeling efforts, which rely on time-iterative techniques to generate the predicted ice accretion. In addition, plans exist to test the array-equipped wing cuff in the Icing Research Tunnel to provide a direct comparison between flight, wind tunnel, and analytical aircraft icing test techniques. Two recent papers describing this work in more detail are appended to this report (refs. 3 and 4).

The future efforts in this area will concentrate on the small-scale physics which control the surface roughness, and the resulting convective heat transfer from the ice surface. This area has been clearly identified as the prime region of uncertainty in the current understanding of the ice accretion process. The effort will combine analysis and focused experiments to identify the physical mechanisms which control the microscale roughness on an accreting ice surface.

ANNOTATED BIBLIOGRAPHY

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