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INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY 1988-1989

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1. INTRODUCTION

There are four areas of research being pursued in 1988 under sponsorship of the FAA/NASA Joint University Research Program, and one area which has been completed. The four active areas were:

- Automatic Speech Recognition in Air Traffic Control
- A Rule-Based Planning and Scheduling System
- Modeling of Ice Accretion on Aircraft in Glaze Icing Conditions
- Cockpit Display of Hazardous Weather Information

The completed project was:

- Terminal Area Flight Generation Using Parallel Constraint Propagation (Sadoune, FTL Report R89-1)

2. AUTOMATIC SPEECH RECOGNITION (ASR) IN AIR TRAFFIC CONTROL

Today, the Air Traffic Control system relies on verbal communication between the air traffic controllers and the pilots of the aircraft in the controlled airspace. Although a computer system exists that processes radar and other information regarding the aircraft, the information contained within the verbal communications is not retained. The introduction of ASR technology would allow this information to be captured. The purpose of this research effort is to demonstrate the feasibility of using ASR technology within the ATC environment and to address the problems involved, especially the relevant human factors issues. Off-the-shelf ASR technology will be used in conjunction with FTL's real-time ATC simulator running on the laboratory's TI-Explorer Lisp machines.

At present, new hardware is being acquired. A paper presented by Joakim Karlsson on this topic at the Ohio University Research Progress Review Meeting in June 1989 is included in this report.

3. A RULE-BASED PLANNING AND SCHEDULING SYSTEM

Planning denotes the formulation of a detailed scheme, program, or method worked out beforehand for the accomplishment of a goal. It involves the analysis of the desired goal and its division into sub-goals which are subsequently treated in the same way until a set of primitive objectives is obtained. A rational plan is prepared by a reasoner for execution by one or more actors or agents who perform actions to achieve the objectives. A reasoner is a cognitive system (human or machine) capable of some level of logical deliberation.

Computers have been employed to assist in the creation of plans almost from their inception. One of the first uses of computers, shortly after World War II, was to solve large linear optimization problems for military planners. However, the actual creation of a plan by a computer did not occur for another thirty years. The reason for this delay is that planning is a cognitive process requiring symbol manipulation, rather than strictly computation. The creation of plans by a computer had to await the development of a mature symbol manipulation language, such as *Lisp*.

A paper presented by Lyman Hazelton Jr. discussing the logical components of a rule-based planning and scheduling system presented at the MIT Research Progress Review Meeting in October 1989 is included in this report.

4. MODELING OF ICE ACCRETION ON AIRCRAFT IN GLAZE ICING CONDITIONS

The work in aircraft icing over the past year has focused on the fundamental aspects of glaze ice accretion, with the goal of improving analytical ice accretion models. Current ice accretion models do not perform well within the glaze ice regime. Glaze icing is characterized by rough and irregular ice accretions and occurs at relatively warm temperatures, i.e., a few degrees below freezing. In this regime the ice accretion is controlled by the removal of latent heat by convective heat transfer. This heat transfer is strongly dependent on the roughness of the ice surface. Current ice accretion models assume a uniform ice surface roughness that is an input parameter in the models. Over the past year, studies have been conducted on the generation of surface roughness on accreting ice surfaces with the goal of providing a deterministic surface roughness in the ice accretion models.

A series of icing wind tunnel tests were conducted at the NASA Lewis Icing Research Tunnel, the B.F. Goodrich Icing Test Facility and the Data Products of New England Icing Test Facility. The ice accretion and surface roughness were observed on simple circular cylinders by visible and infrared photography. Based on these tests, a relatively simple modification to the existing ice accretion models has been proposed. Instead of a single uniform surface roughness, several zones of variable surface roughness are included to correspond with experimental observations. The Multi-Zone model has been implemented in the LEWICE ice accretion code in a preliminary manner and has shown a significant improvement in ice shape prediction in the glaze ice regime. In addition, the experimental and analytical efforts have focused on the need for correlations between the physical surface roughness and the equivalent sand grain roughness which is commonly used in the analytical models.

5. COCKPIT DISPLAY OF HAZARDOUS WEATHER INFORMATION

Information transfer and display issues associated with the dissemination of hazardous weather warnings are studied in the context of windshear alerts. The July 11, 1988 microburst events in which several air carrier aircraft penetrated microbursts during the Denver Terminal Doppler Weather Radar (TDWR) operational evaluation were analyzed in terms of information transfer and the effectiveness of the microburst alerts. Information transfer, message content and display issues associated with microburst alerts generated from ground-based sources were evaluated by means of air carrier pilot opinion surveys and part task simulator studies. A paper presented by Craig Wanke and John Hansman at the Ohio University Research Progress Review Meeting in June 1989 is included in this report.

ANNOTATED REFERENCE OF 1988 PUBLICATION

1. Sadoune, M.M., Terminal Area Flight Path Generation Using Parallel Constraint Propagation, FTL Report R89-1, May 1989, Flight Transportation Laboratory, MIT, Cambridge MA 02139.

A Flight Path Generator is defined as the module of an automated Air Traffic Control system which plans aircraft trajectories in the terminal area with respect to operational constraints. The flight path plans have to be feasible and must not violate separation criteria.

The problem of terminal area trajectory planning is structured by putting the emphasis on knowledge representation and air-space organization. A well-defined and expressive semantics relying on the use of flexible patterns is designed to represent aircraft motion and flight paths. These patterns are defined so as to minimize the need for replanning and to smoothly accommodate operational deviations.

Flight paths are specified by an accumulation of constraints. A parallel, asynchronous implementation of a computational model based on the propagation of constraints provides mechanisms to efficiently build feasible flight path plans.

A methodology for a fast and robust conflict detection between flight path plans is introduced. It is based on a cascaded filtering of the stream of feasible flight paths and combines the benefits of a symbolic representation and of numerical computation with a high degree of parallelism.

The Flight Path Generator is designed with the goal of implementing a portable and evolving tool which could be inserted in controllers' routine with a minimum disruption of present procedures. Eventually, a model of aircraft interaction provides a framework to rethink the notion of Separation Standards.

ANNOTATED BIBLIOGRAPHY OF 1988 PUBLICATIONS

A. Hansman, R.J., Yamaguchi, K., Berkowitz, B., and Potapczuk, M., Modeling of Surface Roughness Effects on Glaze Ice Accretion, AIAA-89-0734, AIAA Aerospace Sciences, January 1989.

Experimental observations from several icing test facilities of ice surface roughness are described. A Multi-Zone surface roughness model is proposed and implemented. Significant improvement in glaze ice accretion modeling for several cases is demonstrated.

B. Hansman, R.J., Kirby, M.S., and Lichtenfels, F., Ultrasonic Techniques for Aircraft Ice Accretion Measurement, AIAA-88-4656CP, AIAA/NASA/AFWAL Conferences on Sensors and Measurement Techniques for Aeronautical Applications, September 1988.

Ultrasonic techniques for aircraft ice accretion measurement are described. Wind tunnel evaluations in the NASA Icing Research Tunnel and flight test evaluations on the NASA Icing Research Aircraft and the Boeing 757 test aircraft are discussed.

C. Hansman, R.J., and Turnock, S.R., Investigation of Surface Water Behavior During Glaze Ice Accretion, Journal of Aircraft, Vol. 26, No. 2, February 1989.

Investigations of the behavior of surface water on accreting ice surfaces are presented. The surface water behavior controls the surface roughness which subsequently influences the convective heat transfer and the glaze ice accretion where heat transfer is the limiting mechanism for ice accretion.

D. Hansman, R.J. and Wanke C., Cockpit Display of Hazardous Weather Information, AIAA-89-0808, AIAA Aerospace Sciences Meeting, January 1989.

Information transfer issues associated with hazardous weather alerts are studied in the context of microburst warnings. Case studies, pilot opinion surveys and part task simulator studies are presented.

E. Hansman, R.J., The Influence of Ice Accretion Physics on the Forecasting of Aircraft Icing Conditions, Paper 5-1, Proceedings of the Third International Conference on the Aviation Weather System, January 1989.

The detailed physics of aircraft ice accretion processes are presented in terms of meteorological variables commonly used to forecast icing conditions. The nonlinear dependence of icing severity on these variables is discussed as well as the consequences for icing severity forecasting.