notion is particularly reflected in the Research, Engineering and Development Plan which is driving toward an ultimate system called "Flow Management". The message which must be stated emphatically is the need to influence the direction which system planners within and outside the FAA must take to incorporate AI efficiently into airspace management. Again, a goal of unconstrained operation to airspace users must be the rule.

ARTIFICIAL INTELLIGENCE AND OTHER ASPECTS OF AIR TRAFFIC CONTROL

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Much of the attention of the artificial intelligence (AI) workshop was focused on direct air traffic control (ATC) issues: conflict resolution, flow control, and weather prediction. This was entirely proper, and the Federal Aviation Administration (FAA) advanced automation program fully concurs with this emphasis. However, rather than reiterate the contributions of others, it would be preferable to use this opportunity as a means of establishing the potential benefit of AI in some of the less direct, but equally important, aspects of ATC. Specifically, the following three topics are suggested: software (SW) design, system repair and maintenance, and training.

Software Design

The reliability of the advanced automated system (and its successors) will be critically dependent on the SW design. Because of the extremely high reliability desired, on the one hand, and the complexity of the SW on the other, it is essential that techniques be used that: 1) minimize the number of hidden faults inadvertently designed into the system; and 2) provide fault tolerance for those that remain. Existing design methods may be enhanced substantially by incorporating AI techniques. Two such techniques come to mind immediately: the use of intelligent search techniques to explore a branching SW tree; and knowledge based systems that make use of expert techniques to solve complex SW design problems.

System Repair and Maintenance

The availability of the ATC system depends critically on rapid failure detection, isolation, and repair. As experience is accumulated on failures, it is likely that this knowledge can be incorporated into an expert system that will reduce system repair time significantly. A second area relates to the detection of incipient expert failures. Again, based upon accumulated knowledge, it should be possible to anticipate many hardware (HW) failures with aid of an expert system. As an aid to maintenance personnel, AI techniques can improve both system performance and personnel productivity.

Training

For the foreseeable future the ATC system will be operated primarily by controllers, with automation being used to aid them, particularly in performing routine tasks. The training of controllers, as well as the operating and maintenance personnel who support them, is thus a key link in the performance of the system. Computer based instruction (CBI) has been used by the FAA for over a decade in the training of these personnel. However, existing CBI, through rote learning techniques, seeks primarily to reduce the number of instructors required for training. Although rote learning may be suitable for routine tasks, the successful operation of the ATC system also requires, from time to time, innovative solutions to new or unpredictable events. As the degree of automation of the ATC system increases this need can be expected to increase. CBI based upon rote learning tends to reject those people who are good at innovation, but bored by routine. Obviously, the ATC system needs both types of people. New and more powerful CBI techniques are now being explored that make use of AI techniques to provide a more versatile learning environment. The development of such a training system for the FAA should be given high priority.

AIRPAC: ADVISOR FOR INTELLIGENT RESOLUTION OF PREDICTED AIRCRAFT CONFLICTS

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SUMMARY

AIRPAC is an expert system being developed to assist air traffic controllers with the planning of resolutions for predicted violations of safe separation or "conflicts" between aircraft. AIRPAC uses knowledge-based system (KBS) techniques to suggest aircraft maneuvers that will prevent a conflict. AIRPAC's choice of a resolution is based on decision rules gathered via consultations with air traffic controllers. By applying these rules to a description of the conflict, AIRPAC produces a single "best" resolution that includes detailed parameters of the recommended aircraft maneuvers. To plan resolutions, AIRPAC uses a hierarchical approach similar to the nested levels of abstraction in a human reasoning process. AIRPAC explains its operation by providing an audit trail of rules used in the search for a resolution. This explanation capability and the representation of resolution rationale in symbolic terms natural to humans are significant benefits provided by the KBS approach.

Introduction

The Federal Aviation Administration (FAA) is undertaking the development of the automated en route air traffic control (AERA) system (1). AERA is intended to automate many of the routine tasks performed by today's air traffic controllers. AERA will also provide computer-based tools for assisting controllers with the more complex planning and control functions requiring human intervention. An important purpose of the U.S. air traffic control (ATC) system is to assure that aircraft are safely separated from one another. An objective of AERA is to predict potential violations of safe separation or "conflicts" between aircraft ten to twenty minutes in advance. These predictions will be based on aircraft flight plans, wind observations, anticipated pilot or controller actions, and other information. If a conflict is predicted with sufficient lead time, AERA can suggest aircraft maneuvers to resolve it in a way that reflects desirable considerations beyond avoidance of imminent collision. The capability to predict aircraft conflicts and plan their resolutions in advance is expected to increase controller productivity and permit more airspace users to fly the routes they prefer.