ISAC: A CBR System for Decision Support in Air Traffic Control

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Abstract. The conflict resolution task performed by air-traffic controllers appears a suitable task for automation using CBR. This is because human competence seems to involve recognising situations and reusing solutions. In this paper we present our experiences in developing a CBR system to support this conflict resolution task. We discuss the problems of case representation: the macro problem of what should constitute a case and the micro problem of how to characterise a case. We evaluate some alternative case representations and identify a representation with one aircraft per case that is extendible to describe conflicts with multiple aircraft.

1. Introduction

In this paper we describe the application of CBR to a real world problem in air traffic control. This application is interesting in itself because of the safety critical issues involved. It is also of particular interest from a CBR viewpoint because of the question of what should constitute a case in this problem domain. At this stage in the progress of CBR research this question is chestnut that has exercised many researchers. CBR is intuitively appealing because it manifestly reflects one of the important ways in which humans solve problems. However the represent-retrieve-reuse model of CBR is often difficult to apply in situations where human competence is obviously reuse-based. This difficulty is almost always associated with the granularity of retrieval and the question of what should constitute a case.

ISAC is a case-based decision support system for conflict resolution in air traffic control (ATC). A conflict occurs in ATC when two or more aircraft pass too close together. It is the air traffic controller’s job to resolve potential conflicts by adjusting the trajectories of the aircraft. This decision involves: selecting the aircraft to manoeuvre, deciding on the type of manoeuvre and determining the details of the manoeuvre. The choice of aircraft to manoeuvre and the type of manoeuvre depend on several factors including:

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the geometry of the conflict, the capabilities of the aircraft, their position relative to their destination, etc. At the moment ISAC assists in the first two stages of this decision making process. The motivation in designing ISAC has been to reduce the decision making burden on controllers. This is of particular importance for the future as air traffic volumes increase. The current version of ISAC can resolve conflict between pairs of aircraft. However, an important design consideration has been that it should be extendible to problems involving three or more aircraft. In a CBR context this involves more complex types of case reuse. It implies that, for reasons of domain coverage, monolithic cases describing individual conflicts are not practicable.

Later in this paper we evaluate some alternatives to this monolithic case structure. In Section 2 we will describe the air traffic control problem in detail. We will also describe HIPS, a next generation visualisation aid for controllers and explain how ISAC interacts with that system. In Section 3 we will present the overall architecture of ISAC and in Section 4 we will describe the alternative case representation options that have been considered. We conclude in Section 5 with an evaluation of the effectiveness of these alternatives.

2. The problem of air traffic control

Despite the fact that modern aircraft are packed with sophisticated electronic equipment, air traffic control has always been more of an art than a science. Ground-based control essentially consists of people following the progress of aircraft represented by points (derived from radar data) on a flat display screen. The simple nature of the data available means that the controllers themselves are required to build and maintain a "mental picture" of extrapolated 4D traffic based on experience and other rather ill-defined heuristics. Having done this, the controller must mentally compare every pair of predicted trajectories to determine whether any pair of aircraft will pass within the minimum permitted separation - in which case he is required to intervene in some way to resolve the potential conflict.

Such an unscientific approach to ATC is, however, becoming less and less acceptable. Pressure for change is coming from two sources: firstly, the ATC world, as elsewhere, is undergoing an information explosion - controllers potentially have access to gigabytes of data of every sort, and the possibility to communicate with aircraft and other ground systems in ways, and at speeds, which were unimaginable when their practices were conceived. Secondly, airlines are demanding greater efficiency and quality of service from the air traffic control providers: efficiency, because ATC currently accounts for about 15% of the price of a ticket, and quality of service to allow airlines to increasingly fly their preferred (and presumably near-optimal) flight paths - this is difficult using today's practices and structures.

The problem cannot, however, be approached from a uniquely technical viewpoint. Removal of the "artisanal" aspects of ATC, particularly with regard to the task of preventing metallic contact between aircraft, touches the very heart of the profession. This means that any enhancement of the controller's skills by some type of automation must be done in a way which is sympathetic to current practices and therefore acceptable to controllers.

A number of attempts have been made to model conflict resolution activity by captur-