Air Traffic Control and Alert Agent

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ABSTRACT

This paper presents an agent program that monitors and interacts with the dynamic situation of flights around an airport tower as well as interacts with a human operator that can override the agent actions. The agent is fully autonomous but presents its decisions to the human user before execution with a timer. When the time expires, the agent will carry out the action. This is an example of shared autonomy between an agent and a human supervisor.

1. INTRODUCTION

We have written a program that assists a tower air traffic control operator. Just as the operator would, the agent monitors the nearby tower sky, processes requests for landing, and instructs the pilots with maneuvers that maintain safe separation distances and collision aversion. The human operator is informed of all agent activities. If there is a possible collision threat, a pop-up window gives details, shows the agent's choice of action, and the countdown time before the agent issues that command. The human operator may interrupt the agent and issue his own command.

This program works along with a tower simulator we have developed [1]. The tower simulator simulates 6 planes flying in a 20 by 20 miles grid around the Grand Forks airport tower. The simulated planes can fly in a straight line, turn left or right, ascend, descend, land or circle the tower. Figure 1 shows the main panel of simulator. The human operator has a simulated view out of tower.

The following data about each plane on the radar is made available to our ATC agent. All ATC data is current and the latest being used by the simulator.

(a) *the plane location*: This is recorded in a three dimensional coordinate system. (x, y) = (0, 0) is the location of the tower and z = 0 when the plane is on the ground.
(b) *the flight direction*
(c) *the flight speed*
(d) *the plane ascend/descend pitch*
(e) *the plane intention to land or their status in holding pattern*

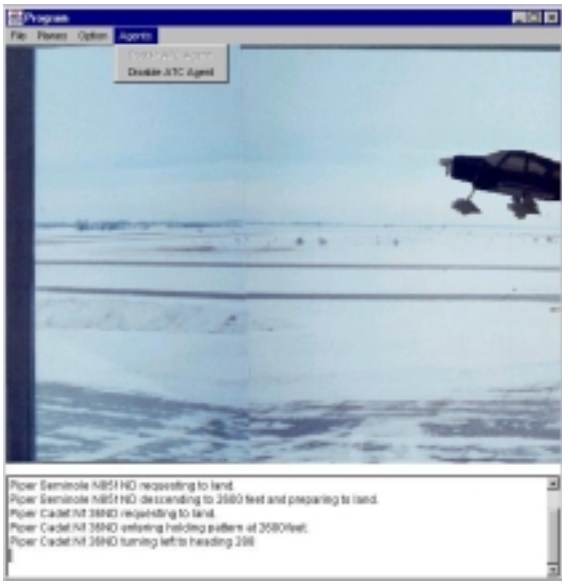

Figure 1. ***The main simulator panel***

The two main functions of our ATC agent are *to detect and prevent collisions*, and *to process landing*. Agent will display dialog boxes for collision detection and when there are requests for landing. The windows will stay open until either it is timed out or the human operator overrides the agent decision. Our agent maintains three queues. The first queue is the landing request queue. Along with a request to land, each pilot generate a landing priority; a number between 0 and 4. 0 is the default priority when here are no unusual circumstances, whereas 4 is the highest priority number corresponding to the most urgent emergency. The landing request queue is arranged with the ascending priority so the most urgent priorities are handled first.

The second queue is collision queue. Planes near enough to pose a collision threat are assigned a priority from 1 to 4. 1 signifies a near miss; whereas, 4 signifies a collision that is about to happen. Later in this paper we will explain how these priorities are a function of distances and flight projections.

The third queue maintains the order of planes that have requested landing but due to high traffic are in the holding pattern.

The ATC agent maintains a combined priority queue of all planes in its radar screen using the range of priorities from 0 to 4. ATC agent may use the pilot's landing priority when there are no other concerns. However, the ATC agent will use other cues for reprocessing its priority queue. In general, the following are the factors that contribute to the agent's determination of priority:
(a) pilot's requests and landing priority.
(b) perception of possible collision threats
(e) projection of paths for planes initially detected to be on a collision course
(c) landing requests from different pilots with priorities that are conflicting with prior requests
(d) planes in various landing stages
(f) status of planes in holding pattern

The agent will issue one of the following commands:
(a) clear to land
(b) go to the holding pattern,
(c) come out of the holding pattern
(d) avoid a collision by a maneuver (turn, ascend, descend)

2. THE COLLISION QUEUE

Distance between every plane is checked against every other plane in the radar range. Distances are checked in the horizontal plane and then comparisons are made in the vertical axis. There are two different sets of collision ranges for determining a collision threat. One range is for flight in the air space before they request landing. This range is two miles on the xy-axis and a 1000 feet between planes on the z-axis. The second range is when the plane or planes are going to be landing or going to be in a holding pattern. This range is one mile apart on the xy-axis and 500 feet between planes on the z-axis. If the separation distances between the two planes are violated, the program will assign a number to correspond to the severity of collision threat. Collision threat is a priority number similar to landing priorities. The numbers range from 1 to 4.

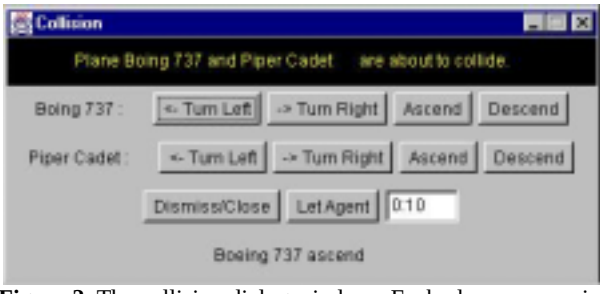

Figure 2. The collision dialog window. Each plane can receive different commands: Turn left or right, ascend or descend. "Dismiss/Close" button will do nothing to the planes, whereas "Let Agent" button will allow the agent to perform the actions being suggested by the agent at the bottom of the screen. When the timer (10 seconds is shown) runs out, the agent will perform the suggested action.

The collision dialog window is shown in Figure 2. The timer is very important; if the air traffic controller does not handle the problem right away there could be an accident. So with the timer insures that either the human operator or the agent will handle the problem. The timer will be set to the severity of the collision threat. The closer the two planes are the less time will be used on the counter.

3. THE LANDING AND HOLDING PATTERN QUEUES

Only a single plane can be landing at a given time and will be given permission to land. All other request for landing will receive a command to enter holding pattern. Holding pattern is a circular flight at a specified altitude. The agent maintains a queue of planes in the holding pattern.

Once the agent receives a request to land, the agent will check to see if they can land. It will have to check to see if any other planes are landing at that time. If a plane is in stage zero, one or two, the agent cannot send another plane to land; it will have to wait until the plane that is landing is past stage two. Then the agent will have to put the planes into a holding pattern around the tower until the landing path is clear. If the first three stages are clear, then the agent can tell the requesting plane it is clear to land. A flight in the holding pattern is given permission to land when the current landing plane enters stage three and is popped from the holding pattern queue.

The landing dialog window is shown in Figure 3. As shown in the Figure, there is two override options that the user can choose: clear to land, and enter a holding pattern.

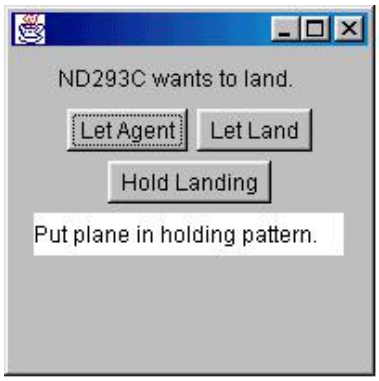

Figure 3. Landing dialog window. "Let Agent" allows the agent to take care of the landing. "Let Land" is used by the human operator to give permission to land. "Hold Landing" is used by the human operator to decline clearance for landing and to send the plane into holding pattern. The agent action is shown in the bottom of display.

REFERENCES

[1] H. Hexmoor and T. Heng, 1999. ATC Tower Simulator: TACUND, Proceedings of **IASTED** on Applied Modeling and Simulation, Cairns, Australia.