

DEVELOPMENT OF LAPTOP PC TOOL WITH VISUAL PROJECTION FOR FLIGHT MANAGEMENT TRAINING

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Keywords: *Flight Management, Crew Resource Management, Decision making, Visual System*

Abstract

Being a public transportation system, airline pilots operate scheduled flight with considering the following factors: flight safety, economical use of fuel to minimize expenditure, punctual flight operation, and passenger comfort. Research into such flight management skill is limited because of high experimental costs and the availability of full-flight simulators. For the purpose of performing the flight management skill research and training easily, we have developed PC software, which displays a simplified flight situation and records the operation history. In order to simulate the flight easily, this software displays cockpit picture which shows some instruments indicating flight information. In order to simulate the flight more realistic and expanding the versatility of the PC software, we have developed the visual display function and applying it to the PC software. Scenery of Haneda airport and surrounding areas are demonstrated in the visual display, and the display is refreshed by updating data based on flight operation. This paper reports the feature of the PC tool regarding the visual display function.

1 Introduction

1.1 Background

The risk management ability to cope with sudden changes of flight condition, with ensuring the flight safety, maintaining the schedule punctuality, saving fuel, and keeping passengers comfort, is necessary for airline pilots. In this paper we use the term “Flight

Management skill” as the mentioned experience-based ability. This ability is considered one of Crew Resource Management (CRM) skills. For the purpose of safety operation, airline carriers want to clarify and visualize such experience-based ability, and want to reflect the results to the airline co-pilot training.

The flight-automation system enables pilots to operate with little difficulty in most of normal flight situations [1]. Even in an emergency situation, for example, an engine fire, the crew follows the non-normal checklist and there is no decision making process [2]. However, in the case of trivial failure in normal flight, the operation depends on the flight management skill of pilots. For example, in the case of a sudden runway closure, pilots have many choice of decision making, and usually all of the solutions do not lead to serious crisis. It is desirable for pilots to find out the best solution among the all possible choices, considering the amount of remaining fuel, weather, air traffic and many other factors. Here, the “best solution” means that the flight operation maintains a high level of the safety, fuel economy, punctuality and passenger comfort. The clarification of such experience-based skill is eagerly desired from airline companies because the research outcome can improve the pilot training system, and increase the customer satisfaction.

There have been many studies of human error in non-normal situations [3–5]. Line-oriented flight training (LOFT) [6], which has the overall objective of improving total flight crew performance, prevents incidents and accidents during operational flying. LOFT gives the opportunity to practice line operations (e.g.,

maneuvers, operating skills, systems operations, and operators' procedures) and CRM skills (e.g., crew coordination, judgment, decision making, and communication skills) in a realistic environment. There have been only a few previous studies researching how airline pilots use their judgment to manage difficult situations during normal flight operation. Baker et. al. [7] developed PC-based training tools to teach CRM skills in normal flight operation. In their scenario, one of the passengers began to complain of chest pains. The crew had to decide what to do and where to go next. Ide et. al. [8] have conducted full-flight simulator experiments and clarified the difference of flight management skill between experienced and inexperienced pilots using a scenario of sudden runway closure due to earthquake. The experimental results demonstrated that the inexperienced pilots tended to divert to other airport quickly, whereas the experienced pilots tended to keep holding while the fuel margin was remaining.

For the research of the Flight Management Skill, we have to carry out a sufficient number of experiments. However, the high experimental cost and the availability of the full-flight simulator are the difficulty of the research.

In order to perform the Flight Management Skill research easily, we have developed PC software. The scenario was the same as the Full-Flight Simulator experiments. The experimental studies, which were carried out using the PC software and the Full-Flight Simulator, demonstrated essentially the same result from the viewpoint of the differences of "Flight Management Skill" between experienced captains and novice copilots. The experienced pilots had the tendency to wait until the runway re-open [9].

The Full-Flight simulator experiments were also conducted for the scenario of encountering wind shear in the landing process, and differences of decision making skills, which were associated with their experiences, were discussed [10]. In the scenario of encountering wind shear, ECHO exists around the holding pattern of Missed Approach Course after the go-around procedure. The operation to avoid the ECHO is necessary for the pilot. In order to

simulate the scenario using the PC tool, the course alteration functions are necessary for the PC tool.

1.2 Objectives

The aim of PC tool development is to reproduce the essence of real flight management in a simplified manner. The use of the laptop computer is assumed because of the easy availability. The PC tool does not reproduce all the components of the actual flight; we have to extract the significant factors that affect the decision-making process in an actual flight. The PC tool displays a simplified flight situation and records the operation history. The obtained time history of the operation is visualized as a time series chart which is used for the analysis of operation.

If the function of displaying the scenery from the cockpit can be added to the PC tool, we can simulate the flight closer to the real flight, and the Full-Flight Simulator. Laptop computers generally equipped with the feature of connection to a projector. The use of this feature considered enable to display the scenery image.

This paper demonstrates the detail functions of the laptop PC tool, which are necessary to the simulation of the earthquake and wind shear scenarios. The PC tool is expected to be used in the airliner copilot training, when the development of the PC tool enabled us to offer a wide variety of scenarios.

2 Development of PC Tool with Visual Projection

2.1 PC Tool Main Window

The main window of the flight management PC tool, hereinafter referred to as cockpit screen, is shown in Fig. 1. The program is started by clicking on the Start button at the lower left of the screen.

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Fig.1 Flight management PC tool main window

2.1.1 Operation of PC Tool

Operation of the airplane is represented by clicking on the button displayed in the cockpit region. Gear, Flap, and Go-around Switch, Airspeed Heading and Altitude Set button are demonstrated on the cockpit picture. The protection and WARNING function, which are equipped in the real airplane, is omitted. This is because, for the use of research and educational purpose, such functions are ignorable. The message that was reported to the cockpit is displayed in the white rectangle area in the cockpit region, and sounds are played simultaneously with the display.

2.1.2 Horizontal Situation Indicator

A horizontal situation indicator (HSI) is displayed at the lower left of the screen. The position of the airplane can be recognized from the HSI display. The checklist, which is executed after the series of operations, is shown at the upper right of the screen. A check mark is displayed by clicking an item on the checklist. When all items have been checked, a “Checklist Complete” message is displayed.

2.1.3 Communication between Airplane and Ground

Communication with the ground is imitated by the management region in the upper left of the screen. In the case of full-flight simulator experiments, examinees use radio to communicate with air traffic control (ATC) and company radio in order to get information on

runway conditions, weather, alternate fuel, etc. at the destination and at other airports. However, in the PC tool case, it is hard to distinguish what is being asked using voice recognition systems. The examinees therefore have to type their question using the keyboard or have to select a choice from a keyword list.

In the management region, there are three input cells, named “Who”, “Where”, and “What” and an [Ask] button. The “Who”, “Where”, and “What” cells correspond to selection of the target (ATC, company), place (RJTJ, 5000 ft, etc.), and question (alternate fuel, runway information, etc.), respectively.

A certain time after clicking the [Ask] button, the answer is displayed with the sound of a voice.

2.2 PC Tool Setting

PC tool software setting files are contained in the wav file directory, def file directory, texture file directory, and heightmap file directory. The directory of wav file, def file, and Texture file contains sound files, configuration files, texture image files, and landform altitude mapping files, respectively. The scenario of the PC tool is mainly defined by the def file. It is possible to show the information and the communication with ATC and company in the white area of the screen.

2.3 Software Development and Execution Environment

Table 1 demonstrates the environments in software development. The operation of the software is checked using two different Laptop computers. The execution environment is demonstrated in Table 2 and 3. In both cases, the real-time processing of the drawing and operation is confirmed.

Table 1 Software Development Environment

OS	Microsoft Windows XP Professional Version 2002 Service Pack 3
Programming Language	C++, Microsoft Foundation Class(MFC), OpenGL
Development Environment	Microsoft Visual Studio 2005 Academic Edition
CPU	Intel® Core™2 Duo CPU E7400 (2.80 GHz)
GPU	Intel® GMA3100
Video Memory	256.0MB
OpenGL Version.	1.4.0

Table 2 Software Execution Environment No.1

OS	Microsoft Windows XP Professional Version 2002 Service Pack 3
CPU	Intel® Celeron® Processor 575 (2.00 GHz)
GPU	Mobile Intel® GMA 4500MHD
Video Memory	256.0MB
OpenGL Version	2.0.0

Table 3 Software Execution Environment No.2

OS	Microsoft Windows XP Professional Version 2002 Service Pack 3
CPU	Intel® Core™2 Duo CPU U7500 (1.06 GHz)
GPU	Intel® GMA X3100
Video Memory	384.0MB
OpenGL Version	1.5.0

2.4 Visual Display Function

2.4.1 Visual Display Window

Visual display function was developed using OpenGL (Open Graphics Library) which provides a software interface to graphics hardware and implements the graphics functionality.

The window of visual display is isolated from the window of main screen, so in addition to showing the cockpit screen and visual display on the same display, it is also possible to show on two different display, or a display and a projector. If the visual display window is unnecessary, we can minimize the window and execute the PC tool only with the cockpit screen.

The image displayed in the window is updated basing on the information of position and attitude, which is computed according to the operation of aircraft. Because the aim of the software development focus on the decision-making of Pilots, high frame rate of the video is not necessary. In order to work on a low specification laptop PC, the frame rate is set as 10fps (frames per second).

Checking of the PC tool operations was conducted using the laptop computers which are shown in Table 2 and 3. The software operated under the condition that the cockpit screen and a visual display was shown, and confirmed that real-time drawing was possible.

2.4.2 Reproduction of Scenery

In order to reproduce the scenery image around Haneda Airport and surrounding area, texture image data are created beforehand and the scenery is drawn using texture mapping. This feature reduces the computational load and it is possible to draw the scenery with fewer vertexes of polygon for complicated landform.

Texture image was created with the reference to the aerial photograph that courtesy of Joint Venture Group for D-Runway Construction in Tokyo International Airport (Haneda Airport) Re-expansion Project. The aviation lights for Haneda Airport runway 34R also reproduced.

For the purpose of reducing the procedure of computation, Vertex Buffer Object (VBO) is mainly used for drawing. High-speed drawing can be expected by using VBO, because of the vertex data are transferred to the memory beforehand. The change of the vision is reproduced by calculating the translation and rotation of the object, which is updated per time using the data of the position and the attitude of the fuselage.

2.5 Added and Corrected Features

2.5.1 Altitude Data

In the scenario of approaching to Haneda Airport, the airplane flies near Haneda Airport, where the altitude is low and the landform undulation is small. So, it is also possible to draw the vision with supposing that the landform is flat. However, in order to supports the simulation of the flight above undulating landform, altitude data is loaded and landform is displayed. The altitude data is obtained from the basis information map of digital elevation model provided by Geospatial Information Authority of Japan.

Using the altitude data of landform, the altitude mapping (Fig. 2) is created by dividing the altitude of the landform into 1021 steps. Figure 2 demonstrated that, the low value giving blue appearance and high value giving red appearance. The altitude mapping corresponds to the after-mentioned texture image, and the x-y pixel coordinates of the texture image is the same as that of the altitude image. The three-dimensional landform model is generated at startup procedure by reading the altitude mapping, converting into the altitude value from RGB value of each pixel, and setting as the coordinates. The program was improved so that we can easily decrease the number of vertex, for the reason that the drawing process does not prevent real-time program execution.

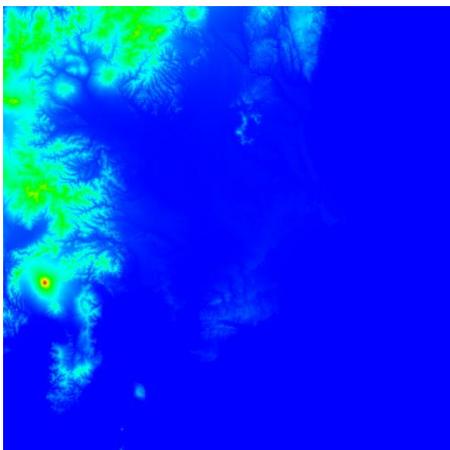


Fig. 2 Contour of heightmap

2.5.2 Creation of the Texture Image

In the case of simulating poor visibility situation near Haneda Airport, we can easily reproduce the vision using the landform data only in the small area close to Haneda Airport. For the purpose of increasing the variety of use, wide area of texture data is generated so that we can reproduce the landform scenery of wide area.

The image used for the texture is also created from the basis map information of digital elevation model provided by Geospatial Information Authority of Japan. The created image is shown in Fig. 3.

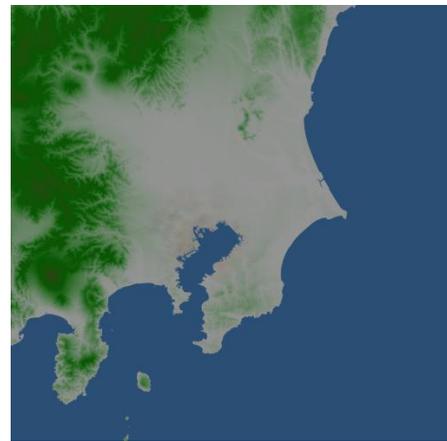


Fig. 3 Texture image of landform

2.5.3 Adding Skydome Object

The skydome is one of the techniques used to create 3D graphics in the simulation of the sky and such other scenery. The skydome object is added for the purpose of reproducing the vision at fine weather. By arranging a hemisphere model in the scene and setting the color, the sky is reproduced from the inside viewpoint. One example of the vision, which is rendered using the altitude data, the texture, and the skydome, is shown in Fig. 4 and 5.

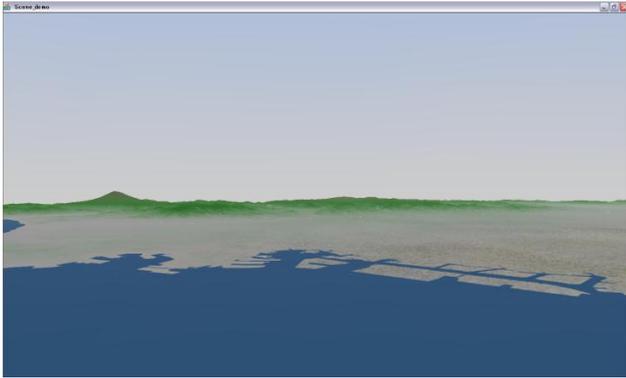


Fig. 4 Scenery image generated by the altitude data and texture image



Fig. 5 Scenery image of Haneda airport

2.5.4 Alteration of Visibility using Fog Function

Visibility can be changed by setting the density of the fog function, which is one of the features of OpenGL. Figure 6 and 7 exhibit the reproduced images of the vision when the airplanes are approaching to Haneda Airport runway 34R at good and poor visibility, respectively.

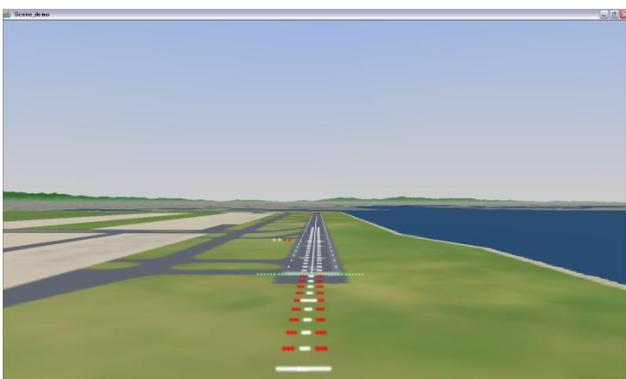


Fig. 6 Scenery image of Haneda airport runway 34R

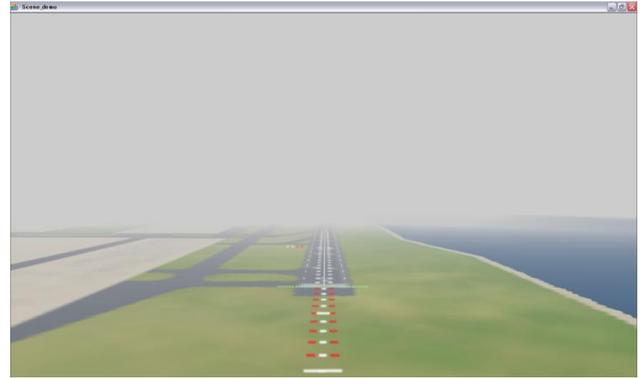


Fig. 7 Scenery image of Haneda airport runway 34R with fog function

2.5.5 Computational Method for Calculating the Approach Route

The aircraft approaches to Haneda Airport runways 34R with the use of ILS (Instrument Landing System). The schematic of ILS is demonstrated in Fig. 8. By correcting the method of calculation which simulates the guidance by Glide Slope, the trajectory to the runway on the route of glide slope can be simulated regardless of the speed.

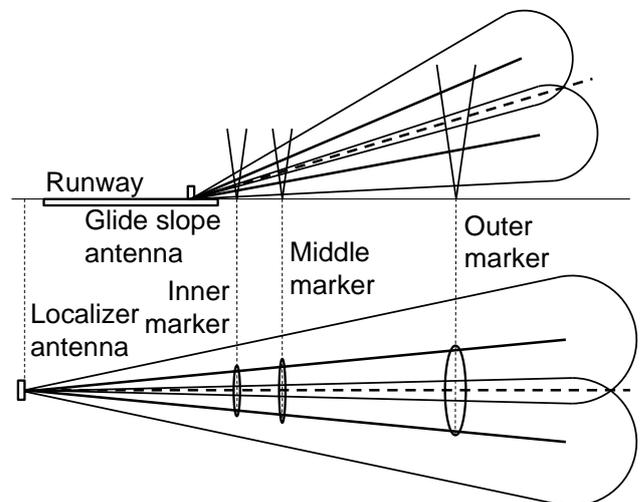


Fig. 8 Radio signals constituting ILS

2.5.6 Examination of Introducing Cloud Object

The reproduction of cloud is considered to be important factor for the decision-making simulation of the airline plots. The method that the cloud can be reproduced by software is also considered. Although the feature is not applied to the PC tool, the development for the implementation is conducted. The image of

cloud in the development phase is shown in Fig. 9.

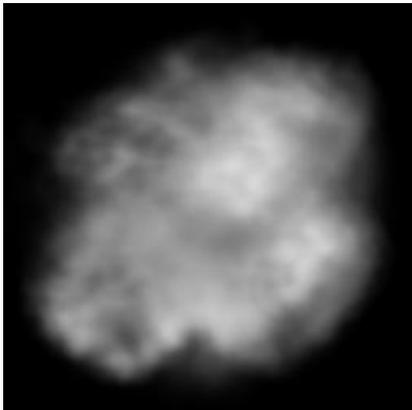


Fig.9 Example of cloud image

3 Conclusion

Research into flight management skill is limited because of high experimental costs and the availability of full-flight simulators. For the purpose of performing the flight management skill research and training easily, we have developed PC software, which displays a simplified flight situation and records the operation history. In order to make it possible to execute the experiment and training in the condition close to the actual flight, vision display feature is added to the flight management PC tool. For the purpose of improving the variation of use and the reproducibility of the vision from the cockpit, altitude data is added and the undulation of the landform is reproduced. By adding the skydome object of OpenGL and using the fog function for changing the visibility, the image of vision is furthermore improved.

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