Analysis of Aerial Images for ILS Inspection

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Abstract. This paper presents an image based navigation system (IBNS), which determines aircraft position and attitude through interpretation of aerial images using a 3-D terrain model. It will be shown by means of simulation and by initial flight tests, that such a system can meet the strict precision requirements for runway-referenced measurements of flight path trajectories. In addition, a laboratory scale experimental system consisting of a robot guided camera will be described.

1 Introduction

In the near term, inertial navigation systems (INS) will remain as a part of on-board navigation systems. Nevertheless, these systems are affected by severe position drift errors, which can be eliminated only by using some other, independent sensors for a positioning update. One possible method to get such position updates is to analyze images acquired on board, using a downward looking digital camera which is fixed to the aircraft. Comparing the analyzed images with a digital map, the camera position and attitude angles can be reconstructed and the desired position update of the aircraft is available. Such systems we will call image based navigation systems, IBNS.

After presenting the system's concept of a model-based IBNS a runway-referenced application will be introduced. This application deals with the completely bord-autonomous calibration of navigation aids such as instrument landing systems (ILS). By means of a simulation it will be shown, that the presented system can meet the very strong accuracy requirements for such a reference system. Moreover the tool of simulation helps to get a deeper insight in some aspects of the system design of IBNS.

To confirm the results of simulation, initial flight test results will be presented. A number of runway approaches were performed while acquiring images with a fixed, forward looking, high resolution CCD-camera. The results of an offline interpretation of these images by the IBNS will be compared with independently gathered data from a reference system. In addition to the flight tests, a laboratory scale experimental system will be described. This system consists of a CCD-camera moved by a high precision industrial robot. Repeatable simulations of runway approaches allow IBNS optimizations and error sources to be investigated.
2 IBNS Concept

A block diagram of the IBNS concept is shown in Fig. 1, where rectangular blocks symbolize processes. Circles stand for data they are dealing with. The following sections will describe the main functional parts of this system.

2.1 Model Generation

A digital map (Digital Terrain Model, DTM) contains an object oriented representation of topologic and cartographic information about the terrain, above which should be navigated. The DTM describes properties of objects in the 3-D world. Each object is described by its geometry and attributes, e.g. the type of object, its class and name. The object’s geometry is represented by the position of the vertices of surrounding polygons in world coordinates (Gauß-Krüger coordinates and the height above MSL).

With a first estimation of the camera’s position and attitude a subset of DTM objects is being projected from 3-D space into the 2-D image plane (Scene Generation, Scene Description). The initial position and attitude data can be obtained by an inertial navigation system (INS). The DTM subset contains those objects, which are suspected to be in the field of view of the sensing device. This