A NAVIGATION AVIONICS FOR SMALL UAVS

Masaru Naruoka, Takeshi Tsuchiya

Department of Aeronautics and Astronautics, School of Engineering, University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, JAPAN

ABSTRACT

In this paper, we suggest a new navigation system for intelligent control of small unmanned aerial vehicles (UAVs). MEMS (microelectromechanical system) sensors and INS/GPS (Inertial Navigation System / Global Positioning System) algorithm allow the navigation system to be small, light and low-cost with high precision. We build a prototype instrument and perform an experiment for comparing it with GAIA, a high-precision INS/GPS device developed by Japan Aerospace Exploration Agency (JAXA). The result shows our system has enough precision exactly.

1. INTRODUCTION

Recently small UAVs have been required to fly more intelligently for extending its application, for example, disaster prevention and security use. In order to carry out these missions, obtaining precise navigation information, like position, velocity and attitude, is essential. This is because with poor precision navigation data, guidance and control routine subsequent to navigation cannot work correctly even if UAVs have excellent performance. Moreover, the existing navigation devices use dedicated components that are big, heavy, and expensive for high precision and they are unsuitable to install on a small UAV. Therefore, we suggest a new navigation system for small UAVs. It is small, light and cost-effective with much higher precision than the traditional method for UAVs that employs an only GPS receiver.

2. NAVIGATION AVIONICS FOR SMALL UAVS

2.1 Overview

As the new navigation system for small UAVs, we propose a strap-down INS/GPS configuration that is composed of MEMS inertial sensors and a civil-use GPS receiver. INS/GPS, which integrates outputs of INS and GPS, is characterized by utilizing respective benefits of them, and provides navigation data more frequently and correctly than GPS alone. Moreover, the strap-down configuration with MEMS sensors and a general-purpose GPS receiver makes it possible to build a small, light and low-cost navigation device. Figure 1 shows the block diagram of our suggested system. In our system, as integration method of INS and GPS we choose extended Kalman filtering that provides the most probable values based on stochastic theory.

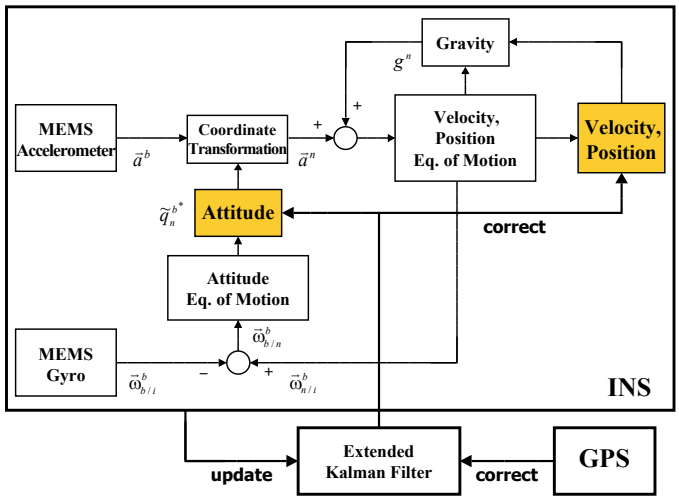

Fig. 1 Suggested system overview

2.2 Prototype

In order to evaluate our proposed configuration, we made a prototype system. Figure 2 and Table. 1 show a look and the specification of the prototype system respectively. For simplicity, a personal computer (PC) connected to the system acquirers the sensor data and implements filtering process of them after the data acquisition. We also confirm that the PC is exchangeable for a small digital signal processor (DSP) unit, which have calculation power enough for the real-time process. According to the prototype, our proposed configuration is small, light and inexpensive enough for installation on a small UAV.

2.3 Experiment

We perform an experiment to compare the prototype with GAIA. GAIA, which is a high-precision INS/GPS device, has enough reliable precision as a reference. The experiment is carried out in flight of an experimental aircraft, MuPAL-α of JAXA. We install the prototype system and GAIA in the aircraft. The sensor data are acquired in horizontal straight flight, steady turning flight and so on. Table. 2 shows the statistical summary of the results and proves that our proposed system has precision enough for navigation of small UAVs.

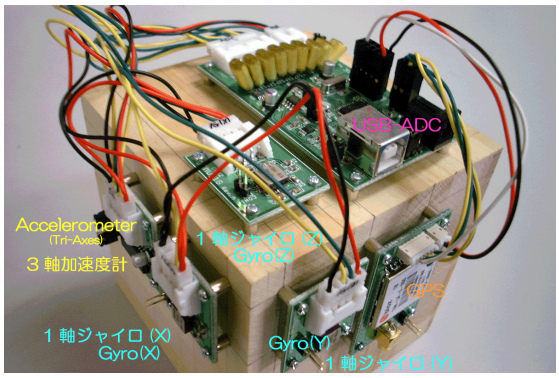

Fig. 2 A look of the prototype

Table. 1 The detail of the prototype

Item	Description
Accelerometer	1 “LIS3L02AS4” made by STMicroelectronics (3-Axes/1-Package, MEMS)
Gyro	3 “ADXRS150”s made by AnalogDevices (1-Axis/1-Package, MEMS)
GPS	1 “TIM-LA” made by u-blox (L1 GPS, 4Hz update)
A/D Converter	1 “AD7739” made by AnalogDevices (100Hz, 24bit quantization)
Interface	USB (“AN2131” made by Cypress)
Size	Under 100 cc without structural element
Weight	Under 30 g without structural element
Cost	About 30,000 JPY

Table. 2 The difference between the prototype and GAIA

	Mean	STD	Worst
Horizontal distance [m]	6.44	2.97	17
Altitude [m]	0.85	2.1	6.9
North speed [m/s]	0	0.12	1.25
East speed [m/s]	0	0.12	-1.13
Down speed [m/s]	-0.08	0.1	-0.67
Roll [deg]	0	0.26	-1.19
Pitch [deg]	-0.67	1.21	-3.9
Heading [deg]	4.17	9.68	23.9

3. CONCLUSIONS

We showed the proposed INS/GPS system is small, light and low cost through our developed prototype system. The flight experiment indicated that our INS/GPS configuration is precise enough for navigation of small UAVs.

References

1. **Naruoka, M.** and **Tsuchiya, T.**, “A Portable and Cost-effective Configuration of Strap-down INS/GPS for General-purpose Use”, *2006 KSAS-JSASS Joint International Symposium on Aerospace Engineering*, (2006).