论文题目：飞控硬件平台设计及导航算法研究

学科名称：控制工程

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摘 要

微小型无人机具有小型化、低成本等优点，在军事领域和民用领域获得了广泛应用。越来越多的场合对其定位和导航能力提出了要求，因此有必要对微小型无人机的导航技术进行研究。

本文首先自主设计了基于ZYNQ-7000和微机电系统传感器的低成本微小型无人机飞控硬件平台，为提高复杂算法的执行效率和实时性，在该硬件平台上设计了基于QNX实时操作系统的软件结构。其次，为减小传感器存在的系统误差对导航算法性能的干扰，研究了相应的误差补偿算法校准各个传感器：用静置法校准三轴陀螺仪；用六面校准法校准三轴加速度计；用椭球拟合算法和在线学习法校准三轴磁力计。为降低传感器噪声的干扰，使用相应的滤波算法对传感器进行滤波处理：用均值滤波处理三轴陀螺仪、三轴加速度计；用滑动窗口滤波处理空速计；用一阶低通滤波处理气压计。最后，本文重点研究了微小型无人机的导航算法。该部分首先在自主设计的飞控电路板上实现了基于互补滤波的姿态解算算法，用GPS接收的速度和经纬度作为导航结果，而后实现了基于扩展卡尔曼滤波的多传感器数据融合算法，该算法融合了陀螺仪、加速度计、磁力计、空速计、气压计和GPS的信息，计算出飞行器的姿态、速度和位置。该算法在GPS失锁时，仍然能够得到较好的导航信息。

经过对所设计的飞控实验平台的实际飞行测试，基于扩展卡尔曼滤波的数据融合算法能够稳定实时的计算出飞行器的导航信息，将该算法用于航点跟踪任务时能够良好的完成任务，验证了算法的有效性、实用性，以及所设计的飞控硬件实验平台的可靠性。

关键字：微小型无人机；互补滤波；扩展卡尔曼滤波；数据融合

Title: Design for Flight Control Platform and Research on Navigation Algorithm

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Abstract

The micro unmanned aerial vehicle (UAV) has been widely applied in military and civilian due to its advantages of small size and low price. The recent applications of UAV require better ability of position and navigation from UAV, and further research on navigation technology should be made.

Firstly, a low cost flight control platform, which integrated ZYNQ-7000 and MEMS sensors, is developed in this paper. The software core is based on a real time operating system on this platform, which can improve the execution efficiency and real-time performance of complex algorithm. Secondly, the algorithm of error compensation is carried out to calibrate the sensors used in this paper, so as to achieve navigation algorithm with higher accuracy. The three-axis gyroscope is calibrated by leaving the gyroscope standing; The three-axis acceleration is calibrated using the six plane calibration method; The three-axis magnetometer is calibrated using ellipsoid fitting and online learning method. Filters are used to reduce the noise of sensors used in this study: mean filter is used to reduce the noise of three-axis gyroscope and three-axis acceleration; sliding window filter is used to reduce the noise caused by the airspeed meter; first order low pass filter is used to the noise caused by the barometer. Finally, this paper focuses on the algorithm of navigation in micro UAV. The algorithm of attitude calculation based on the complementary filtering is applied on the platform. The velocity and the position received from GPS is used to show the performance of the navigation algorithm. The algorithm employs the extended Kalman filter which fuses measurements from the sensors including gyroscope, acceleration, magnetometer, airspeed meter and barometer. The algorithm bears the advantage of high robustness, and if the GPS information is lost, navigation can be still available in this