Biological phenomena found in nature can be learned and customized to obtain innovative engineering solutions. In recent years, biologists found that birds and bats use their mechanoreceptors to sense the airflow information and use this information directly to achieve their agile flight performance. Inspired by this phenomenon, an attitude control system for micro air vehicles using rich amount of airflow sensor information is proposed, designed and tested. The dissertation discusses our research findings on this topic. First, we quantified the errors between the calculated and measured lift and moment profiles using a limited number of micro pressure sensors over a straight wing. Then, we designed a robust pitching controller using 20 micro pressure sensors and tested the closed-loop performance in a simulated environment. Additionally, a straight wing was designed for the pressure sensor based pitching control with twelve pressure sensors, which was then tested in our low-speed wind tunnel. The closed-loop pitching control system can track the commanded angle of attack with a rising time around two seconds and an overshoot around 10%. Third, we extended the idea to the three-axis attitude control scenarios, where both of the pressure and shear stress information are considered in the simulation. Finally, a fault tolerant controller with a guaranteed asymptotically stability is proposed to deal with sensor failures and calculation errors. The results show that the proposed fault tolerant controller is robust, adaptive, and can guarantee an asymptotically stable performance in case of a large scale of 20% sensor failures.