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RESEARCH INTERESTS

I see research as an expression of the same drive that took explorers into uncharted wilderness a century ago. Eager anticipation, tedium punctuated by excitement, and a great deal of luck are all hallmarks of both research and exploration. Success is determined in large part—and, unfortunately, this is particularly clear in hindsight—by the choice of where to explore. For some, the ragged edge of theory is entirely appropriate. For me, I've found that other fields often contain ideas that can be applied to the vastly different set of problems I'm working to solve.

My graduate research has been in the area of system integration of complex autonomous systems. While my primary focus has been GNC (guidance, navigation, and control), I have worked with and developed knowledge in embedded systems, electronics, aerodynamics, and structural engineering. My thesis was the design, construction, and experimental validation of a full-scale autonomous catamaran. This solo project required me to perform system design and integration work in all of these areas before building the catamaran.

Within that project, I was able to adapt several ideas from prior research in different fields. The wingsail propulsion was derived from a way to reduce pilot stick loads in aircraft earlier in the century. The basis of the novel attitude system was to take a single equation out of a survey paper on the control system of the satellite "Clementine," and apply it to an entirely different system. Lastly, a novel method for implementing the extended Kalman filter that was proposed for a radar tracking problem was the seed that led to the non-linear two-step algorithm that I developed to calibrate the magnetometers on the sailboat.

I believe that autonomous operation is at an inflection point. The combination of modern system analysis with new sensors and small low-cost and low-power electronics enable autonomous operation in areas that have previously been either too expensive or too difficult to achieve. Thus, platoons of ground, air, marine, or even space vehicles can be used for environmental monitoring, as distributed sensor arrays, or other applications yet to be discovered.

The benefits of system integration and control engineering are certainly not limited to autonomous operation. While at Stanford, I saw these concepts transform navigation systems. It is clear to me that similar improvements are possible in medical devices, UAVs (unmanned air vehicles), transportation systems, micro-satellites, and many more. An interdisciplinary approach has shown to yield substantial gains in performance and cost over current technologies.

I recently attended a lecture by the Surrey Satellite Systems Ltd. During the lecture, the problem of fitting an epicycle orbit to the GPS data was posed (due to power requirements, the GPS receiver is powered only 15% of the time). Though they approached the problem with a Kalman filter, it appears to me that the same algorithm that I had developed for the magnetometer calibration could be used to better solve this problem with slight modification.

I look forward to collaborating with both faculty members and industry engineers to identify new applications and areas of future research. I cannot imagine a better area to explore, to apply what I've learned in system integration and control engineering, than micro-satellites. Micro-satellites represent the frontier of capability, reliability, and cost-where my knowledge of robust networks, condition-based monitoring and fault isolation, diagnostics and fly-while-failed systems, system identification, GPS, and modern control theory can be best applied.

These disciplines, coupled with upcoming advances in microelectronics, MEMS technologies, and solar cells will allow the creation of micro-satellites that accomplish real science while remaining within real budgets. I look forward to contributing to that achievement.