

Research Proposal

It has always been my dream to be a great researcher, to come out with innovative products that no one has done before. My experience in these four years of undergraduate course in NUS gave me the motivation to realize my dream. I am excited to know that securing a PhD career in NUS would lead me to this goal.

1 Experiences

I started my research experience in an undergraduate project module EE2001 in NUS. In this project, my team came out with an idea of building an Unmanned Ground Vehicle (UGV) which navigates in the hospital as an automatic guided trolley. Throughout the module, I have gone through the process of research, integration of components, implementation of algorithms in programming, and the tuning of the controller during the test runs to obtain a better performance.

Our hard work is rewarded with good grades in this module. In addition, our UGV is placed on the display rack in the same laboratory. The picture and descriptions of our UGV also appeared in the modules introduction note later as a good example of past years work.

My research work for my Final Year Project in NUS focuses on designing a mini rotorcraft Unmanned Aerial Vehicle (UAV) which can navigate in the indoor environment. In the absence of GPS signal, the UAV is able to retrieve information on its position based on gyroscopes and accelerometers. It is further corrected with the aid of a vision system through a camera mounted below the UAV. It is able to perform take off/landing, and navigates by following a path on the ground in a fully autonomous mode.

In the coming March, I will be leading the team to take part in the Singapore Amazing Flying Machine Competition 2010 using the mini UAVs we built. We expect to be the first ever team to finish the tasks in a fully autonomous mode in this competition.

2 Research Plan

My research interest mainly focuses on the development of the UAV. In particular, I am interested to take up the challenge to develop a Micro Aerial Vehicles (MAV), which is also known as, miniature UAV.

2.1 Motivations

MAVs are significantly smaller than previously developed UAVs. Its tiny size realized the ability of navigation in the indoor environment. It can be widely used in remote observation of hazardous environment which is not accessible by other unmanned vehicles. Its potential usages in military application cause the current development of MAVs to have a high research value.

2.2 Proposed Specifications

In my current Final Year Project in NUS, I am building a controller for a rotorcraft UAV with approximately 46cm in dimension and 800 grams in total weight. I am aiming to develop a rotorcraft MAV with a target dimension of lesser than 20cm under 100 grams payload including the weight of the bare helicopter. In the absence of GPS signal in an indoor environment, vision navigation system will be used to replace the GPS navigation system. I will also work further on the controller to improve its robustness in terms of performance and disturbance rejections.

2.3 Potential Challenges

Weight

The weight of the whole system including a bare helicopter, an onboard processor for autopilot control, cameras for vision navigation, an inertia measurement unit as sensors to provide feedback, and a battery strong enough to power all the components and motors for at least 10 minutes, is to be maintained under the 100 grams requirement. Smaller and lighter hardware components are much needed for this.

Absence of GPS signal

GPS signal will not be available in the indoor environment. Navigation system will be switched to vision based navigation once GPS signal is not detected. More cameras and better image processing algorithms are needed in order to provide precise measurements.

Control Methodologies

Due to the small size and light weight of the MAV, it is easier to be affected by disturbances such as wind gust or changes in battery voltage. Robust control method (such as H-infinity) is necessary since MAV is with ultra small size and light weight, its robustness should be fully guaranteed. Nonlinear control technique can extend its flight capacity and enhance the flight performance.

3 Academic Targets

It has always been my aim to get my works recognized at the international level. If I am able to get into NUS to pursue my PhD career, I will not focus solely on the studies but also put in more effort on other academic activities such as publishing scientific papers in the top international technical journals, and participating in international conferences to share my works and at the same time getting to know the latest works by other people all around the world.

Currently I have submitted an international conference paper to the *IEEE R8 International Conference on Computational Technologies in Electrical and Electronics Engineering* with the title “Autonomous Mini-UAV for Indoor Flight with Embedded Onboard Vision Processing as Navigation System” which describe my research in the Final Year Project. I am looking forward to participate in this conference to share my research work on mini-UAV and to equip myself with the latest knowledge.

With the facilities and the working environments I have experienced in my undergraduate research in the UAV research group in NUS, I believe that NUS can provide me the knowledge and the resources to fulfill my dream of getting my research works introduced globally. I expect opportunities to participate in the famous international conferences to broaden my view during my PhD career in NUS.