

Senior Design Projects:
UAV Sensing and Control

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Topic List

- **Light-Weight/Accurate Altimeter for a Small UAV**
- **Gyro-Stabilized Servo-Driven UAV Sensor Platform**
- **Light-Weight/High-Quality Electrical Power Generation**
- **Miniature RF Doppler Speed and Range Sensing Device**
- **High Precision and High Sampling Rate USB-Based ADC**
- **Video-Based Small UAV for Autonomous Search and Rescue**
- **Development of Small Quad-Rotor UAV**
- **Sonar Vision (See the Sound)**
- **Real-Time Data Link for AFRL Data-Table**
- **Programming with Graphics Processing Unit (GPU) for Computer Vision Applications**

Light-Weight/Accurate Altimeter for a Small UAV

- Accurate altitude information is very important in many UAV operations, such as navigation, target tracking, geo-location, etc.
- GPS only provides absolute altitude information w.r.t. to sea level. We need relative and local altitude information.
- Possible approaches:
 - pressure meter: used mostly in current small UAVs, inexpensive, but inaccurate and easily affected by weather conditions
 - laser range finder: accurate, but reading frequency and vertical sensing geometry are issues
 - RF device: accurate but could be complicated
 - computer vision: could be accurate and complicated
 - other devices or combination of the above approaches
- Require light-weight, high accuracy and reliability for small UAV applications.
- Accuracy requirement: less than 0.1 meter at 100 meter altitude.
- Reading frequency requirement: more than 30 Hz.
- Shouldn't be too expensive.

Gyro-Stabilized Servo-Driven UAV Sensor Platform

- UAV sensors, such as cameras, require stable sensing condition.
- Small UAVs cannot meet this sensing requirement; a stabilization device is needed.
- Two mostly used approaches:
 - mechanical gyro:



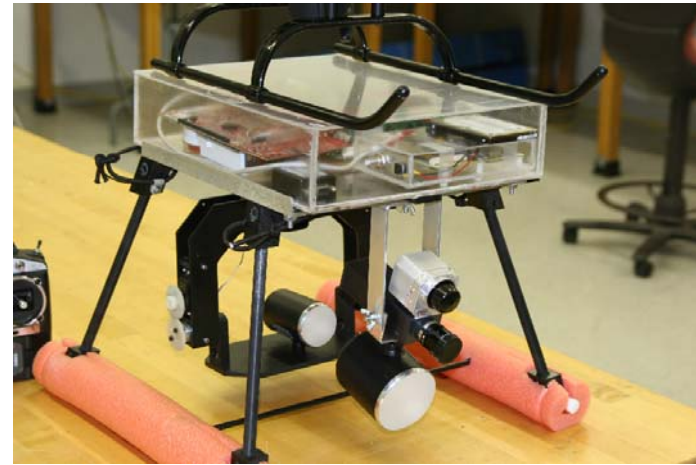
Reliable, but heavy and consuming large amount electrical power.

- Electronic gyro and servo:
Reliable, light weight and consuming little electrical power. Require stabilization in pan and tilt.



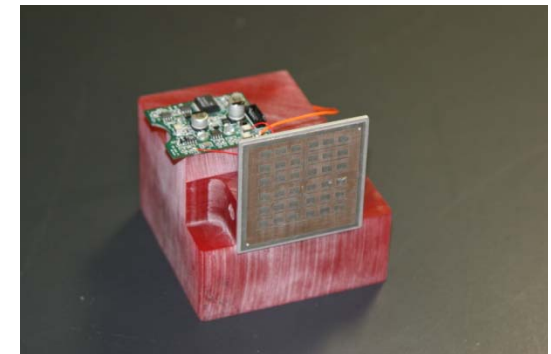
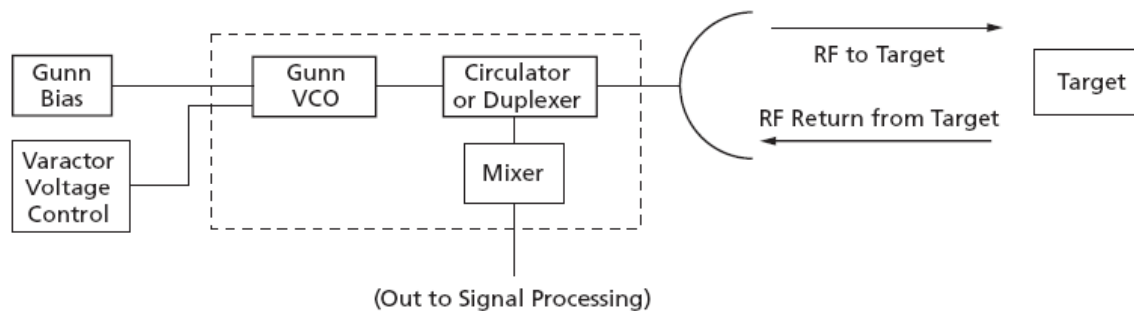
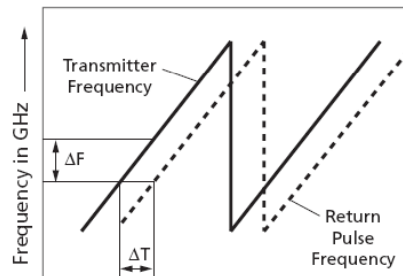
Light-Weight/High-Quality Electrical Power Generation

- Many electronic devices on a small UAV require substantial amount electrical power (more than 500 watts) over an extended period (more than 2 hours). Besides, the quality of the power needs to be high: stable and no ripples. Batteries cannot meet such requirements.
- A gas engine has a high power-weight ratio. The idea is to use a gas engine to drive a brushless motor to generate electrical power. A voltage stabilization and regulation circuitry is needed.
- Requirements: light-weight (less than 3 lbs including fuel tank), compact, 12 V and more than 500 watts, high quality, last more than 2 hours.



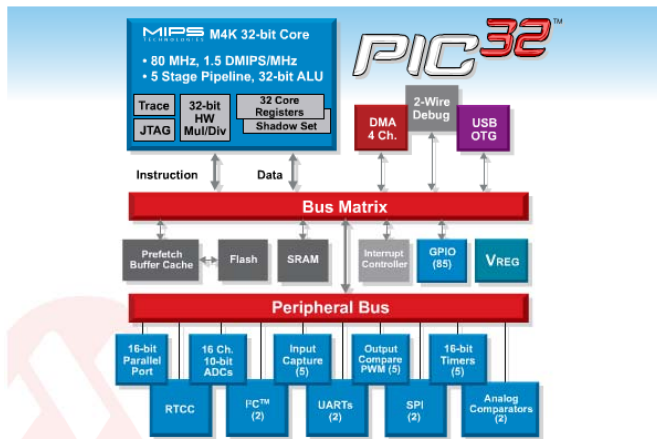
Miniature RF Doppler Speed and Range Sensing Device

- Objective: design and fabricate a miniature microwave Doppler speed and range sensing device, using COTS RF components (such as VCO).
- The device has many applications: (1) measuring vehicle speed: police radar and true ground speed for agricultural vehicles, (2) detecting motion: intrusion alarms, (3) measuring range: automobile braking systems. The device can also be used in industrial control applications, such as counting objects moving on a conveyor belt, measuring vibration in machine parts or measuring levels of liquid products, etc.
- Need to generate both speed and range measurements with a compact device.



High Precision and High Sampling Rate USB-Based ADC

- An analog-to-digital converter (ADC) is a device which converts continuous signals to discrete digital numbers.
- There are several important specifications of an ADC, including resolution, accuracy and sampling rate.
- The objective of this project is to design and build a high precision (16 bits), high sampling rate (150k per channel) and low cost (< \$200) ADC.
- The ADC should have at least 4 channels and the USB interface capability.
- A precise time stamp needs to be recorded along with data.
- A microchip processor (PIC32) and a USB interface board will be used to support programming flexibility.



PIC32 signal flowchart



USB interface board

Video-Based Small UAV for Autonomous Search and Rescue (S&R)

- Autonomous search and rescue capability is a critical component in many S&R missions.
- Small UAVs play an important role in search and rescue.
- Stabilizing and controlling a small helicopter is very challenging.
- The objectives of this project are: (1) to stabilize a small helicopter, (2) to equip the helicopter with remote sensing capability, and (3) to enable the helicopter with autonomous search and rescue capability.



A TRex 450 helicopter



An autopilot for stabilization



A small video camera and
tracers for sensing and
communication

Development of Small Quad-Rotor UAV

- A quad-rotor UAV has many advantages over a traditional helicopter UAV, including more stable dynamics and easy to control.
- The objectives of this project are: (1) to design and build a quad-rotor UAV and (2) to stabilize the quad-rotor UAV with an autopilot.

More details will be given if you are interested in this topic.

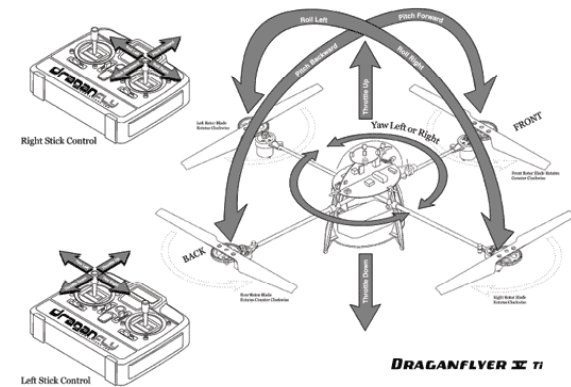
Samples of Quad-rotor UAVS



DraganFly quad-rotor



Stanford quad-rotor (Starmac II)



Control of a quad-rotor

Sonar Vision (See the Sound)

- Sonar and video are two different types of sensors: one active and the other passive.
- Precisely fusing sonar and video is very challenging.
- The project is to precisely pinpoint the source of sound and overlay it on video data.
- The strength of the sound is also displayed by color. So you can see the sound on the video data.

More details will be given if you are interested in this topic.

Programming with Graphics Processing Unit for Computer Vision Applications

- A graphics processing unit (GPU) has many parallel processors which run pixel level tasks very efficiently.
- Computer vision has many low level tasks that can be implemented in parallel.
- The project is to program GPU for KLT tracking, image registration, mosaic, and other computer vision tasks.
- Require certain computer vision knowledge and skills in C++ and OpenCV

