Digital Cameras in UAV for Military and Civilian Use

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Agenda

- UAV communications architecture
- Why the need for cameras?
- Understanding camera features
- UAV applications and camera selection
- Selecting the right camera
UAV Communication Architecture

- UAVs provide a variety of technologies:
  - Computer control
  - Sensors
  - One or more digital cameras
  - Geospatial processor
  - Wireless communication
Why the Need for Cameras?

- Flight control
- Situational analysis
- Aerial photography
- Perimeter/border control
- Pipeline/high tension wire monitoring
- Scientific research
- Mapping
Understanding Camera Features

• Matching features with the application is critical:
  ▫ Image quality
  ▫ Sensor technology
  ▫ Camera shutters and blur
  ▫ Image format
  ▫ Data interface
  ▫ Robust construction
  ▫ Sensor resolution
  ▫ Low noise
  ▫ Lensing
  ▫ Frame rates
  ▫ Flexibility
  ▫ Software Development Kit
Image Quality

- Most critical part of the application
- Need to ensure image provides necessary info
- Price-to-performance ratio
- Factors that influence quality:
  - Sensor, speed, noise, lensing, lighting, image processing, compression
- NIIRS – rating for image quality
Sensor Resolution

- Sensor formats:
  - Small: 0 to 16 megapixel
  - Medium: 16 to 50 megapixel
  - Large: >50 megapixel
- Higher resolution sensors provide:
  - Finer/more details in the image
  - Less need to stitch images together
    - Better colour balance throughout final image
    - Less computer processing time per image
    - Less cameras required
  - Fewer aircraft and/or fewer passes needed to image target area
  - Missions can fly at higher altitudes while achieving same detail
Sensor Technology

- **CMOS**
  - Near IR to Visible light (200 to 1100nm)
  - Typically smaller pixels with lower fill factors
  - Fast readout

- **CCD:**
  - Near IR to Visible light (200 to 1100nm)
  - Typically larger pixels with close to 100% fill factors
  - Slower readout

- **SWIR**
  - Short wave IR (1.4 to 3µm)
  - Used for night vision
  - Requires light to be reflected off objects to see (similar to visible light)

- **LWIR**
  - Long wave IR (8 to 15µm)
  - Detects thermal signatures – measures temperature and emissivity
  - Requires no external illumination
Low Noise

- Direct correlation between camera’s sensitivity and noise
  - More noise = less sensitive
- Low light conditions require low noise cameras
- Less noise = more detail and true color images
- Different types of noise: read, dark current, PRNU, temporal
- How to manage noise?
  - Start with a good quality camera
  - Adjust settings to optimize performance
  - Apply simple s/w algorithms to minimize noise in captured images
Camera Shutters and Blur

- Mechanical vs. electronic, rolling vs. global
- Shutters reduce smearing
- Fast shutters lead to faster frame rates and less smearing
- Short integration times minimize blur
  - Drawback: sensor needs more light to compensate
  - Highly sensitive cameras help reduce blur
Lensing

- Good lenses greatly contribute to capturing quality images
- Higher resolution cameras require high performing lenses
  - Difficult for lens manufacturers to remove visible glass artifacts, therefore more expensive to build
    - Better lenses provide better images
- For UAV, need lenses that provide control for focus, iris and zoom
- Must properly match lens with sensor technology and size
Image Formats

- UAV applications typically capture RAW images:
  - Provide added control for image processing
  - Application has full control over brightness, contrast, sharpness
  - RAW files typically provide higher bit depth (12 or 14 bits/pixel) vs. JPEG (only 8 bits/pixel)
  - Can render finer details with additional bits
Frame Rates

• Look for highest frame rate for resolution
• Higher frames rates allow more images to be captured, which means:
  ▫ More overlap when stitching images
  ▫ UAV can travel faster, therefore shorter flight times and increased covertness
  ▫ Provides increased number of real-time updates
• Factors that limit higher frame rates:
  ▫ Resolution, integration time, low light, sensor readout time, volume of data to be processed
Data Interfaces

• Cameras require high-speed interfaces to quickly move image data
• Using a standard interface makes interoperability easy and flexible
  ▫ Talk to flight computer, ground control, store images, etc.
• Ability to process, analyse, store and distribute data in real time
• HDMI, GigE and USB buses commonly used
Flexibility

• Helps keep costs low:
  ▫ Valuable for small to mid-sized organizations needing a wide range of applications on a limited budget
• Allows for interchanging cameras based on mission specifics
• Standard data interfaces help by:
  ▫ Allowing cameras to be changed on the fly
  ▫ No need to rewrite/extend or control software for each camera
Robust Construction

- Cameras need to withstand flight shock and vibration
- Light and compact to fit
- Civil Applications: commercial-grade cameras are sufficient
- Military Applications: COTS is becoming more of a trend to keep costs low
Software Development Kit

• Beneficial for customizing camera to application

• Allows integration of camera controls into onboard control computers

• Provides additional features/functions in addition to standard camera control, including image processing, flat field correction and data threshold
UAV Applications and Camera Selection

- Real time video
- Large field of view imaging
- Low light/nighttime video/imaging
- Target/threat tracking
- Thermal imaging
Picking the Right Camera

• Assess application requirements:
  ▫ Daytime vs. nighttime, NIR vs. thermal
  ▫ Frame rate vs. resolution, data transfer speed
  ▫ Distance to object/target
  ▫ Lens control
  ▫ Gimbal mounting and control
  ▫ Size and weight vs. robustness
  ▫ Real time video vs. single image capture
Lumenera Corporation

- Canada’s leading manufacturer of high performance digital cameras for industrial, scientific, security and astro applications
- Specially focused on delivering custom OEM imaging solutions
- USB 2.0 and 3.0, HDMI, Ethernet and Gigabit Ethernet
- VGA through 32 megapixel resolutions
- CCD and CMOS technologies
- Lumenera camera models in UAV applications include the Lg11059, Lw235 and Lw565
Questions

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Thank you