Lab to Business Technology Presentation 4

February 15, 2023

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Railroad bridge inspections using UAV and 3D laser imaging

An Unmanned Aerial Vehicles (UAVs) and Laser Camera based system to inspect the condition of railroad bridges in static and dynamic load conditions

- Developed by University of New Mexico researchers
- Technology transfer managed by UNM Rainforest Innovations in Albuquerque, NM.

Contact UNM Rainforest Innovations

- Arlene Young at ayoung@innovations.unm.edu or 505-272-7886.

Railroad bridge inspections using UAV and 3D laser imaging

Technology overview description

- Utilizes Unmanned Aerial Vehicles (UAVs) and 3D laser cameras collect structural health data from remote and inaccessible locations on bridges
- Data collected includes both bridge performance (displacement) and bridge condition (inspection)

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Railroad bridge inspections using UAV and 3D laser imaging

Problem Description

- Bridge inspections are required annually as part as the bridge management program and follow the American Railway Engineering and Maintenance-of-Way Association (AREMA) recommended practices.
- There are significant challenges that affect railroad bridge inspections today:

  (1) railroad bridge inspectors need to evaluate visually all of the bridge structural elements. This is a major challenge in tall and long steel bridges where elements are difficult to access.

  (2) visual observations without measurements can't quantify defects, they are in general subjective and depend on the inspector carrying them; and

  (3) current inspection methods have difficulty quantifying the dynamic response of bridges to railroad crossing events and in measuring the performance of railroad bridges under live loads. To measure displacements under traffic, a reference point needs to be installed at the field, which is costly and sometimes not possible.

Railroad bridge inspections using UAV and 3D laser imaging

Technology solution

- Unmanned Aerial Vehicles (UAVs) and 3D laser cameras collect structural health data from remote and inaccessible locations on bridges
- Observation data includes bridge performance (displacement) and bridge condition (inspection)
- The technology challenge is that structural displacements tend to be small, and the UAV is itself in motion.
- This challenge is addressed by measuring relative movement of the UAV and the structure; and equipping the UAV with an onboard vehicle motion sensor to measure individual movement of the UAV.
  - The individual movement of the UAV may then be subtracted from the relative movement of the UAV and the structure

Railroad bridge inspections using UAV and 3D laser imaging

Market opportunity

- There is a need for robust, flexible, effective, low cost, and easily deployed technologies for structural displacement measurement.
- There are about 140,000 miles of rail track across the United States. On average, there is presently one bridge for about every 1.4 miles of track.
  - 40% of the United States' freight tonnage is carried by railroads.
  - About 50% of the railroad bridges are more than 100 years old.
- Inadequately maintained bridges can result in train derailment or slow the advisable speed of trains.
- Technology has potential for other infrastructure applications:
  - road bridges, pedestrian bridges, buildings, antennas, dams and other structures
  - seismic events, floods, extreme heat or cold, or high winds.

NOTE: UAV based inspection is showing to be very cost effective relative to traditional methods. Usually providing better results.

Railroad bridge inspections using UAV and 3D laser imaging

IP and Collaboration

- Patent number US 10,641,898 B1
  - Application filed: April 3, 2017
  - Assigned to: University of New Mexico
  - Patent issue: May 5, 2020
  - Adjusted expiration: minimal, expect April 2037
- Open to collaboration
  - There is ongoing research and funding
  - Selected this technology to present because the patents had cleared. There are numerous other patents and technologies in development at UNM and other Universities

Technology Maturity

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Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

A next-generation remote sensing instrument with advanced scientific capabilities for Multispectral Imaging, Detection and Active Reflectance (MiDAR)

NASA Ames Research Center (ARC)

- Mountain View, CA
- Moffett Federal Airfield in California's Silicon Valley

- For technology questions, contact Jay Singh at NASA Ames Research Center
  - Email: jayinder.singh@nasa.gov
- For NASA licensing support, contact Cory Abercrombie
  - Email: cory.m.abercrombie@nasa.gov

Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

Technology overview description

- The MiDAR utilizes both an active transmitter and a receiver for cost-effective solution multispectral imaging system.
- Independent of ambient light or sunlight.
- Can be used for image underwater

Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

Problem Description

- Typically, the Sun is the electromagnetic radiation source whose energy is reflected by the object, then collected and measured by sensors.
- A disadvantage of measuring the Sun's reflected energy in remote sensing is the effect of the Earth's atmosphere.
  - Atmospheric gases, such as water vapor, carbon dioxide, and ozone, absorb radiation and limit the electromagnetic wavelengths available for terrestrial and aquatic remote sensing.
- Atmospheric and water column calibrations are required to estimate the interference and reverse the effects of the atmosphere and water column on the Sun's reflected light rays.

Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

Technology solution

- Active remote sensing technologies using radio waves (Radio Detection and Ranging [RADAR]) and lasers (Light Detection and Ranging [LiDAR]) allow for remote sensing largely independent of ambient illumination conditions.
  - Such approaches provide sufficient transmitter power over the background irradiance and exploit phase information to overcome attenuation and distortion along the optical path.
- Allows for control and design of illumination frequency bands and pulse width
  - "The MiDAR transmitter emits coded narrowband structured illumination to generate high-frame-rate multispectral video, perform real-time radiometric calibration"
- Can also provide a high-bandwidth simplex optical data-link under a range of ambient irradiance conditions, including darkness.

Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

Market opportunity

- Multispectral Remote Sensing from aircraft, robotic explorers, spacecraft, and underwater environments in both low-light and normal lighting conditions
- Hyperspectral Imaging
  - Precision agriculture opportunities
- Simultaneous Optical Communications
- Mineral identification
- UV/fluorescent imaging from UAVs
- Noninvasive medical imaging and diagnosis
- Semiconductor imaging and engineering structure analysis

Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

IP and Collaboration

- Patent Number US 10,041,833
  - Patent Issued: Apr. 17 , 2018
  - Application filed : April 7, 2017
  - Assigned to National Aeronautics and Space Administration (NASA)
  - Anticipated expiration: April 5, 2037
- Collaboration opportunity, yes

Technology Maturity

- Demonstrated 7-channel NASA-developed MiDAR transmitter and receiver
  - Working 10 channel and other versions

Multispectral Imaging, Detection, and Active Reflectance (MiDAR)

A next-generation remote sensing instrument with capabilities for Multispectral Imaging, Detection and Active Reflectance (MiDAR)

For further information contact:

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Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

A 3-D, stereoscopic vision system that fuses visible, infrared and multispectral images from multiple cameras for maneuvering unmanned or autonomous vehicles

AKA **Orthoscopic fusion platform**

Lab info

- Air Force Research Laboratory 711th Human Performance Wing
- Ohio

Contact: TechLink, DOD's Tech Transfer partner.

- Derek Mayer at TechLink
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- David Scott at TechLink
  - Email: david.scott@techlinkcenter.org

Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

- **Technology overview description**
  - A 3-D display for autonomous or remotely piloted vehicles is to allow operators of those vehicles to aggressively maneuver in a complex or dynamic environment.
  - This may also be beneficial in piloted vehicles, providing those operators with additional visual information related to the environment through which the driver and vehicle are traversing.

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Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

Problem Description

- 3D displays are rapidly becoming a popular entertainment medium, but their use in tactical settings are not so well defined.
- Stereoscopic cameras that could capture images for display on a 3D display are well known; however, these cameras alone do not provide any additional information that would not have already been available to the operator
- Conventional cameras may receive or record RGB data that adequately replicate colors for human viewing.
- Does not include full the spectrum of visible light reflecting off of an object, which may contain details that are lost with three-channel sensing of RGB data.

Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

Technology solution

- Bio-inspired approach based on human visual perception scientific research, information from color low-light-level (LLL), short-wave infrared (SWIR), long-wave infrared (LWIR, thermal).
  - LLL TV camera can sense colors under very low ambient lighting conditions.
  - NIR can render night-time scenes that are illuminated only by starlight.
  - SWIR can penetrate atmospheric haze.
  - MWIR and LWIR are sensitive to temperature differentials and readily show hot objects such as humans, fired weapons, and vehicles.
  - NIR, SWIR, MWIR, and LWIR can be used to break camouflage.
- Solid-solid state sensors and cameras are algorithmically fused to yield high-information 3-D video images in real time.

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Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

Market opportunities

- Military and first responders focused but can have other applications
- Can adjust sensors and frequencie based on imaging goals
  - Search and rescue, surveillance, target detection, weapons aiming, aerial reconnaissance, 3-D mapping, navigation, underwater observation, space object analysis
- System output can be converted and displayed on most any of the multitudes of available 3-D display technologies

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Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

IP and Collaboration

- Patent Number US 9,948,914 B1
  - Patent Issued: Apr. 17 , 2018
  - Application filed : May 2 , 2016
  - Assigned to Secretary of the Air Force;
  - Expected expiration: Sept 2036
- Collaboration opportunity, yes

Technology Maturity

- Good experience with multi/hyper spectral technologies
- Working into 3D

Hyperspectral 3D vision sensor for autonomous vehicles and unmanned systems

A 3-D, stereoscopic vision system that fuses visible, infrared and multispectral images from multiple cameras for maneuvering unmanned or autonomous vehicles

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Thank you for attending today's event

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