Evaluating Whether to Enter a Building During a Fire

ND EPSCoR Lesson Plan

Lesson Title: Evaluating Whether to Enter a Building During a Fire

Lesson Overview: Analyze and evaluate how UAVs can be used to determine a buildings safety and stability during a fire.

Topic(s): Engineering, Unmanned Aerial Vehicle (UAV), Thermal Imaging

Grade or Grade Band: 6-8

Lesson Objectives:
Students explain how to use UAVs for building surveying.
Students learn how to fly UAVs and map UAVs path.
Students describe how to use UAVs to analysis for building stability and safety.

National Next Gen Standards:
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

North Dakota Standards:
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Time Needed (estimate) Two 50 minute lessons

Lesson Author: Brittany Hagen
Dr. Brittany D. Hagen is an Associate Professor of Education and CAEP Accreditation Coordinator at Mayville State University in Mayville, ND. Dr. Hagen teaches courses related to foundations of education, educational technology, educational assessment, and elementary methods. Additionally, she has developed both online and classroom curriculums for a variety of age groups, including teach-the-teacher programs, assessment data modules, and high school aviation facilitator guides and interactive student activities. Dr. Hagen is also a proud Mayville State alumnus, dedicated to developing highly effective teachers who share a passion for educating young learners.

Scientist/K12 Collaborator & University: Mijia Yang and Xin Bai

Scientist Bio/Research: Dr. Mijia Yang is an associate professor at NDSU, who has worked in structural health

monitoring and sensor development for many years. Dr. Yang has successfully managed dozens of projects and published more than 100 papers and project reports. He previously led and participated in more than 3 projects involved in the structural health monitoring of composite laminates and bridges, which included (a) The development of An Over-Height Collision Protection System of Sandwich Polymer Composites Integrated with Remote Monitoring for Concrete Bridge Girders; (b) An Integrated Real-Time Health Monitoring and Impact/Collision Detection System for Bridges in Cold Remote Regions; (c) Drone Assisted Drive-by Inspection of Bridges. Dr. Yang also worked in smart painting sensors through two projects, such as Automatic highway marking revealing through self-heating geopolymer concrete and A Novel Durable, Healable and Conveniently Removable Pavement Marking Material Suitable for Both Permanent and Temporary Marking Uses funded by the NCHRP IDEA program. Through these past projects, Dr. Yang has accumulated enough experience on drive-by and UAV bridge inspection, bridge condition assessment, as well as sensor development.

One of the major challenges in the structural engineering profession is timely post-disaster evaluations (FEMA 2000). From the past experiences, the first 24 hours are critical in an event like fire. In fact, it has been shown that UAVs can be used for post disaster surveillance of structures (Panda et al. 2019). In addition, it has been observed that a number of structures resting on spread footings responded better to seismic excitation and kept high integrity, after some earthquakes in China and Japan (Mergos and Kawashima 2005). However, the concerns about risk level of these structures due to fractures and disjoint that could possibly lead to tipping-over failure and collapse of the structure.

Recently many researchers have conducted image based structural health monitoring on bridges (e.g., Moller, 2008, Hiasa et al. 2018). Their major findings reveal that image based structural health monitoring possesses many desirable characteristics such as noncontact, convenient, prompt, and accurate. However, most of these researches focus on bridges, instead of buildings. Compared with bridges, configurations of building structures are more complex and load paths are more versatile.

Therefore, this project will summarize imaged based health monitoring techniques, enhance the autopilot tool for building surveillance purposes, and develop an on-time and onsite assessment tool for risk evaluation of post disaster buildings. The integrated stress analysis with updated structural configuration and image analysis will provide an accurate risk predication for immediate rescues. The research outcome will benefit the structural engineering field with a robust and economic post disaster surveillance and assessment methodology and provide a platform to integrate the stress and image analysis.

Preparation/Materials

Background knowledge students must have to be successful:
Students should have a background in how technology and engineering are used to solve real world problems. Students should understand that new technologies can have impacts on society and the environment, including positive, negative, and unintended consequences. When evaluating technology solutions, it is important to consider benefits, cost, safety, and reliability. It is also critical to consider social, cultural, and environmental impacts of technology.

Differentiation and accommodation to support learning for all students:

When designing any lesson, it is important to address the needs of all learners. Please refer to the following resource for ideas on how to adjust your lesson to accommodate your students' particular learning needs: https://www.understood.org/en/learning-thinking-differences/treatments-approaches/educational-strategies/common-classroom-accommodations-and-modifications

Essential Terminology:
Unmanned Aerial Vehicle (UAV)- an aircraft piloted by remote control or onboard computer.

Image processing – a method of using a computer to process digital images .

Thermal imaging- a method of improving visibility of objects in a dark environment by detecting the objects' infrared radiation and creating an image based on that information.

Infrared radiation- portion of electromagnetic spectrum that extends from the long wavelength to the end of the visible-light range to the microwave range.

Resources:
Unmanned aerial vehicles (UAV) - drones
Enter or Not Enter a Building After a Fire PowerPoint
Enter or Not Enter a Building After a Fire Frayer Model Graphic Organizer
Evaluating Whether to Enter a Building During a Fire Handout

Websites:

- https://www.youtube.com/watch?v=LkUtw1LV4ic
- https://www.flir.com/discover/instruments/manufacturing/thermal-imaging-cameras-for-warehouse-asset-protection
- https://www.youtube.com/watch?v=x5bt-SCYWmc
- https://www.youtube.com/watch?v=CCzUvgJB51A
- https://www.youtube.com/watch?v=ydn2x5ima8o
- https://www.youtube.com/watch?v=Ih_ayi318X0

Materials needed:

Lesson 1:

- UAV (Drones)
- Whiteboard
- Enter or Not Enter a Building During a Fire PowerPoint
- Enter or Not Enter a Building During a Fire Frayer Model Graphic Organizer

Lesson 2:

- Enter or Not Enter a Building During a Fire PowerPoint
- Enter or Not Enter a Building During a Fire Handout

PowerPoint – found as separate attachment

Procedure/Activities

Lesson 1 Sequence: Fundamentals of UAVs and Flying UAVs (50 minutes)

Engage:

1. Ask students what they know about Unmanned Aerial Vehicles (UAVs). Write their ideas down on the whiteboard. Ask students how UAVs or drones can be used to survey buildings for stability and safety. Record these ideas on the board as well.

Explore:

2. Show students the following video about using a drone for roof inspection services: https://www.youtube.com/watch?v=LkUtw1LV4ic (PPT Slide 4). After watching the video, revisit the students' list of idea for use of UAVs and drones to see if they discussed roof inspection services.
3. To introduce vocabulary to students, assign individual students or a small group of students to complete a Frayer Model on each of the following vocabulary terms: Unmanned Aerial Vehicle (UAV), image processing, thermal imaging, and infrared radiation. Use the Frayer Model graphic organizer to complete this activity. Once all students or groups have completed their graphic organizers, share them with the whole group and consider displaying them in the classroom for reference later on during the lessons.
4. Introduce some background information UAVs. UAVs are an unmanned aerial vehicle (an aircraft piloted by remote control or onboard computers) like drones. UAVs are used for quickest data collection, better performance, and extendable platforms (PPT Slide 5).
5. Remind students of the ways UAVs can be used to inspect buildings and roofs. With the whole group, discuss highlight fire safety and building stability (PPT Slide 6).

Explain:

6. Discuss with students that UAVs can follow a designed path using remotes (consoles) to fly over designated targets. UAVs can scan a building according to a designed route. UAV uses features to capture images of buildings this can be done with feature extractions, attaching specialty hardware to the UAV, or image processing methods like edge detection, template matching, assisted structural surveying, or image-based integrated structural assessment (PPT Slides 7-13).
7. (Optional): On PPT Slides 14 – 30 showcase the engineering research conducted by Mijia Yang and Xin Bai at North Dakota State University.

Extensions for learning more about this topic:

8. With access to a drone or series of drones, the instructor leads students through **either** a UAV demonstration of how UAVs can be programmed to follow a designed path **OR** have lab groups (3-4 students) follow the specific brand of UAVs directions to allow them to design a path within the instructors designated area. The ABAQUS software could be used (PPT Slides 31-34)
9. Whether instructor chooses to perform demonstration or have students program their own flight path, instructor will walk students through the software of choosing a flight path and flying the UAV. Note that many UAV software has the option to have pre-made paths. For time purposes, instructor can make 2-5

pre-made paths and students groups can then choose from one of the pre-made path options in the software to perform.

10. Direct students to the designated fly area for either the demonstration or for student groups to have the UAV fly its designed fly path. This can be in the classroom or outside depending on size of drone.

11. Instructor allows clean up time to get drones packaged up correctly and neatly.

12. Optional: Review these resources for more information: https://www.flir.com/discover/instruments/manufacturing/thermal-imaging-cameras-for-warehouse-asset-protection and https://www.youtube.com/watch?v=x5bt-SCYWmc

Evaluation of learning (formative or summative task)

13. If instructors choose the option for the demonstration, instructor can ask students the question found on PPT Slide 35. Have students discuss with shoulder partner or lab partners then discuss student answers in large group.

Lesson 2: Evaluating Stability and Safety of Buildings (50 minutes)

Engage:

1. Instructor passes out the Evaluating Whether to Enter a Building During a Fire handout. Review handout directions with students.
2. Watch the video https://www.youtube.com/watch?v=ydn2x5ima8o and have students take notes found on the Evaluating Whether to Enter a Building During a Fire handout (PPT Slide 38).
3. After the video, discuss the answers to the video notes to ensure all students have the appropriate answers (PPT Slide 39).

Explore:

4. Explain to students that by using UAVs and thermal imaging, fire crews can monitor and diagnose the condition of a structure or building. Thermal imaging relies on collecting data of different temperatures. This data uses specific temperatures to show how these differences in temperature can determine where a specific point of damage is in a structure or building. Thermal imaging does not just show damage of a building but also helps crew to locate the specific location of the fire or see through smoke.
5. Put students in groups (2-4 students) and direct them to do Part 2 of the Evaluating Whether to Enter a Building During a Fire Handout (PPT Slide 40). After students have finished Part 2, have student groups share answers. Students should understand from Part 2 that the thermal imaging colors represent different temperatures of the fire. That red indicates the hottest location of the fire and that the images show that the fire is on the second floor of the building only. A thermal imaging color scale can be found in the PPT Slide 41.

Explain:

6. Explain to students that they now understand how to read a thermal image indicating the location and difference in temperatures, they will now do Part 3 on the Evaluating Whether to Enter a Building During a Fire Handout (PPT Slide 42).
7. Instructor walks around room, helping, redirecting, or answering questions when necessary.

Extensions for learning more about this topic:

8. Review these resources for more information: https://www.youtube.com/watch?v=Ih_ayi318X0

Evaluation of learning (formative or summative task)

9. Consider asking the extension questions on PPT Slide 43 to further extend learning on the topic of UAV thermal imaging.

Additional Lesson Resources / Materials

References:

- "Delta Episode 10- Using Thermal Drones to Assist Fire Fighting Operations." *FLIR*, January 2019, https://www.flir.com/suas/delta/delta-episode-10/
- Jakubowski, Greg. "Thermal Imaging Cameras Help Firefighters See Through Smoke." *Fire Rescue Magazine*, 1 Nov. 2010, firerescuemagazine.firefighternation.com/2010/11/01/thermal-imaging-cameras-help-firefighters-see-through-smoke/#gref.
- Lufkin, Bryan. "These Drones Can Fight Fires Using Thermal Imaging." Gizmodo, 11 Dec. 2015, https://www.gizmodo.com.au/2015/12/these-drones-can-fight-fires-using-thermal-imaging/
- "Thermal Imaging Cameras (TICs) High-Rise Fire Fighting." *HIGH-RISE Fire Fighting*, June 2013, www.highrisefirefighting.co.uk/tic.html.

Websites for purchasing materials

Lesson 1:

- UAV/Drone
    - https://www.homedepot.com/p/CONTIXO-RC-Drone-with-Camera-Foldable-Quadcopter-Drone-Gimbal-1080P-HD-Wide-Angle-Lens-WiFi-GPS-Best-Drone-for-Beginners-F22/310006327