TDEM
THE TEXAS A&M UNIVERSITY SYSTEM

EMERGENCY MANAGEMENT USE CASE

Research Title:	**Computer Vision for 'Reburn' Detection in 'Smoldering Fire' Areas and Suppression System with UAVs**
Author(s):	Dr. Burchan Aydin, Dr. Mutlu Mete, Cody Logue, and Venkat Oruganti
Description:	Employing an artificial intelligence supported real-time computer vision algorithm, the drone system aims to detect any potential reburns in smoldering fire areas outside the main wildfire periphery, triggering fire extinguishing UASs. These UASs, with 50 lbs. payload capacity, are equipped with a remotely controlled dropping mechanism carrying a batch of biodegradable water balloons filled with vinegar and soap, and another batch of balloons filled with baking soda and water. By using balloons, the need for a heavy tank is eliminated. As the balloons are dropped onto the predetermined reburn spots, they explode to release the contents, which results in a chemical reaction between the vinegar and the baking soda. This chemical reaction creates water, carbon dioxide, and sodium in a foamy texture. This output combination helps suppression of reburns or cooling down of the smoldering fires.
When Applied:	- It should be practical in smoldering fire zones, where the fire has already swept through, but there are still left-over vegetation and heat. As the air and ground crew are focusing on the main lines, a team could be sent to these smoldering zones to monitor, detect, and suppress/cool down reburns without interrupting the fire control efforts. It is a supplemental emergency management application. - The system could also be applied during wildfire seasons, when the fire danger level is high, very high, or extreme on state forests, or near critical infrastructures.
Who Applies:	Texas A&M University – Commerce
Disaster Type:	Wildfires
Infrastructure Affected:	Any infrastructure that could be damaged by wildfire
Industry Affected:	Any industry on the path of a wildfire
Where Applied:	Wildfire prone areas, near critical infrastructure
Agency Affected:	Texas A&M Forest Service, USDA Forest Service
VOAD Affected:	N/A
Who/What Affected:	Firefighters and civilians
How Affected:	If the reburns in smoldering fire zones can be controlled, the risk of firefighters being entrapped within several fires will be minimized. Risk of fire spread from smoldering areas could be minimized. Fire control time will be shortened, more lives and infrastructure could be saved. Firefighter fatality and injuries could be lessened.
Timing of Application:	It could be applied before, during, and after a wildfire. - For fire prevention in high, very high, or extreme risk zones to monitor, detect, and suppress spot fires, ember casts) - During the fire, outside the main fire front periphery in smoldering fire zones

	- After the fire, to cool down hotspots
Critical Points:	- A controlled field experiment is needed. Preferably, a 10x10 feet-square area will be burned, turned into a smoldering fire zone. Collaborating firefighters will be present in the field experiments to prevent any unwanted outcome. - The proposed research project uses a ground station, an exploratory drone, and an extinguishing drone. The ground station is the control hub for our proposed system. The ground station operator is the decision maker in the light of real-time information and visualization provided by exploratory drone. The operator may investigate the active fire area manually or within the autopilot mode. The exploratory drone is equipped with thermal sensors, color (RGB) camera, and on-board processing units to detect the reburns. The active reburn areas which satisfies operators conditions (temperature, area, location) will be declinate automatically before transmitted to the ground station. The exploratory drone computer makes all required calculation on-board, such as thermal-color image registration, area calculation, and prioritization reburns areas. Once a detected area is above a certain temperature and size threshold, the exploratory drone marks the location and relay the location coordinates back to the ground station for confirmation. After verifying the smoldering area, an F.A.A certified drone pilot will deploy the first extinguishing drone to the given coordinates. After the payload drop, if further suppression is needed, the second extinguishing drone will be deployed while the first one is being refilled with payload. - The extinguishing drone has a camera pointing directly downwards, with two laser pointers attached at an angle to ensure a payload drop with low tolerance for error. The angles of these laser system will be further tested before the field experiments. Accuracy of the results will be measured by recording the deviations from the target. - The extinguishing drones have biodegradable balloons as payload. A batch of balloons are filled with water and baking soda, while another batch of balloons are filled with vinegar and soap. The number of balloons needed for each batch will be tested, together with the proportions of each component before the field experiment. Cooling down capacity will be measured by recording before drop and after drop temperatures of smoldering fire, and flame existence. The researchers have already partially tested and proved the effectiveness of this approach. One extinguishing drone is ready and tested where balloons were dropped on a target, successfully. The second extinguishing UAS is planned to be purchased with potential funding from this proposal and will be a replicate of the existing UAS. - Our software system prioritizes the larger and hotter area in attempt to aid firefighter operators. This means that in the events of many reburn areas, the operator will receive multiple reports that will be addressed in order from largest to smallest and hottest to coolest.

What Benefit:	Preventing additional fires igniting in already extinguished areas. Controlling smoldering fires. Prevention of spot fires in high, very high, or extreme fire danger zones
Where Used:	This is a novel approach using the chemical reaction between vinegar and baking soda and further increasing the effectiveness by using water and soap. The system has only been tested in Texas A&M University – Commerce off-site field.
Additional Research:	The City of Commerce Fire Department is ready to collaborate with the research, unless Texas A&M Forest Service would be willing to allocate a use case location.
Additional Information:	By contacting the researchers
Expert Contact:	Dr. Burchan Aydin burchan.aydin@tamuc.edu Dr. Mutlu Mete Mutlu.mete@tamuc.edu
Original Research:	This research was initiated on Fall 2022 and has not been published yet. Publication work is in progress.
What Risks:	The researchers do not anticipate any risk as the collaborating firefighters will be present.
Partner Agencies/Jurisdictions:	The City of Commerce Fire Department

Research with a Technology Component Should Respond to the Following Questions

Research Requested:	No
Why Better:	Current standard to extinguish the reburn area requires firefighter attendance. This is a tedious, dangerous, and costly operation. Our smart-UAS based solution can increase firefighter safety, save time, and reduce operational costs in wildfire management.
Reliability:	The drones are controlled by experienced drone pilots with F.A.A. certification for sUAS Remote Pilot for this use case. Pre-flight checklists are completed before each flight. In any scenario where autonomous flight fails, remote pilots can take over the flight manually. Any crash risk is at minimum but considering the worst-case scenario, the payload we use (vinegar, soap, baking soda, water) are not classified as hazardous. The thermal camera and drone parts are easily replaceable and widely available on the market. Only issue would be the LiPo battery explosion in a crash situation, but the suppression effect of our payload would neutralize that.
Support Needed:	We use drones and cameras available in the market. The custom software is provided and maintained by the Texas A&M University-Commerce.
Citizen Impact:	No
Training Required:	An F.A.A. sUAS remote pilot license is required to operate drones for this application. Extinguishing solution preparation instructors will be provided in the manual as well.
Public Accountability:	Proposed system does not record/share/transmit any private data.

Please Note: Questions or suggestions regarding the Use Case Template may be directed to Dr. MacGregor Stephenson at the Texas Division of Emergency Management at macgregor.stephenson@tdem.texas.gov.

Texas Division of Emergency Management (AEMGP) Feb or March, 2023 - 5/10/23	Year 1	TOTAL
Salaries		
Aydin, Burchan	$0.00	$0.00
Mete, Mutlu	$0.00	$0.00
A. Senior Personnel Total	$0.00	**$0.00**
Subtotals	**$0.00**	**$0.00**
Fringe Benefits		
Aydin, Burchan	$0.00	$0.00
Mete, Mutlu	$0.00	$0.00
C. FRINGE BENEFITS Subtotals	**$0.00**	**$0.00**
Total Salary & Fringe	**$0.00**	**$0.00**
G 1. Materials & Supplies	**$8,995.00**	**$8,995.00**
G. Other Expenses / Other Direct Costs	**$0.00**	**$0.00**
E. 1. Domestic Travel	**$0.00**	**$0.00**
H. Total Direct Costs	$19,994.00	**$19,994.00**
I. Total Indirect Costs	$0.00	**$0.00**
Total IDC Base	$8,995.00	**$8,995.00**
J. Total Direct and Indirect Costs	$19,994.00	**$19,994.00**

Year 1 Direct Costs:	$19,994.00
Year 1 Indirect Costs:	$0.00
Year 1 TOTAL AMOUNT:	$19,994.00

BUDGET CALCULATOR - YEAR 1

SALARY AND FRINGE CALCULATOR FOR FACULTY AND STAFF

9 MONTH CONTRACT FACULTY SALARY AND FRINGE BENEFITS

Name	Role	Annual Base Salary	ACADEMIC YEAR (AY)								*One month salary= Annual salary/9				Salary	Fringe	9-month contract Faculty/Staff Salary and Fringe
			FALL SEMESTER				SPRING SEMESTER				SUMMER						
			% Effort	FALL PM	Salary	Fringe	% Effort	SPRING PM	Salary	Fringe	% Effort	SUMMER PM	Salary	Fringe			
Aydin, Burchan	PI		0.00%	0.00	$0	$0	0.0%	0.00	$0	$0		0.00	$0	0.00	$0	$0	$0.00
Mete, Mutlu	Co-PI		0.00%	0.00	$0	$0	0.0%	0.00	$0	$0		0.00	$0	0.00	$0	$0	$0.00
														Subtotals:	$0	$0	$0.00

BUDGET

TOTAL SALARY AND FRINGE BENEFITS FOR ALL FACULTY AND STAFF	TOTAL Salaries for ALL Faculty/Staff	TOTAL Fringe for ALL Faculty/Staff	TOTAL Salaries and Fringe for All Faculty and Staff
	$0.00	$0.00	$0

EQUIPMENT	One Heavy Payload Octocopter ($11,500)	$10,999.00
	Subtotal:	$10,999.00

SUPPLIES	Water storage tank ($100)	$100.00
	High pressure water pump to fill balloons ($150)	$150.00
	PVC piping, hoses, valves, and nozzles for refill station ($100)	$100.00
	55 gal White Vinegar ($200)	$200.00
	50 lbs Baking Soda ($60)	$60.00
	5 gal Dawn dish soap ($150)	$150.00
	Dedicated laptop and drone telemetry system ($1300)	$1,300.00
	Control System ($1,100)	$1,100.00
	Release mechanism to drop payload ($100)	$100.00
	4x – 3s 10,000 mAh batteries ($40/each)	$160.00
	FPV kit ($275)	$275.00
	Onboard flight computer for image processing ($700); NVIDIA 945-82771-0000-000 Jetson TX2 Development Kit; https://www.amazon.com/NVIDIA-945-82771-0000-000-Jetson-TX2-Development/dp/B06XPFH939	$700.00
	Multiple 4-lane 4K camera solution for Jetson Xavier™ NX FLOYD carrier board ($350)	$350.00
	FLIR HADRON 640R HIGH PERFORMANCE, DUAL THERMAL AND VISIBLE OEM CAMERA MODULE and SDK ($4250)	$4,250.00
		$0.00
	Subtotal:	$8,995.00

OTHER EXPENSES		$0.00
	Subtotal:	$0.00

DOMESTIC TRAVEL (Includes Canada, Mexico & U.S. Possessions) (Mileage is $0.625)	Traveler:	Flight(s)	Registration(s)	Hotel(s)	Mileage	Perdiem	Total
		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
						Subtotal:	$0.00

TOTAL DIRECT COSTS		$19,994.00
TOTAL INDIRECT COSTS	**Modified Total Direct Cost:** 0% of the total direct costs excluding equipment costing > $5,000/each, tuition reimbursement, patient care costs, student support costs, the excess of $25K of each subaward, alterations and renovations, and space rental or rental maintenance.	$0.00
TOTAL DIRECT AND INDIRECT COSTS		$19,994.00