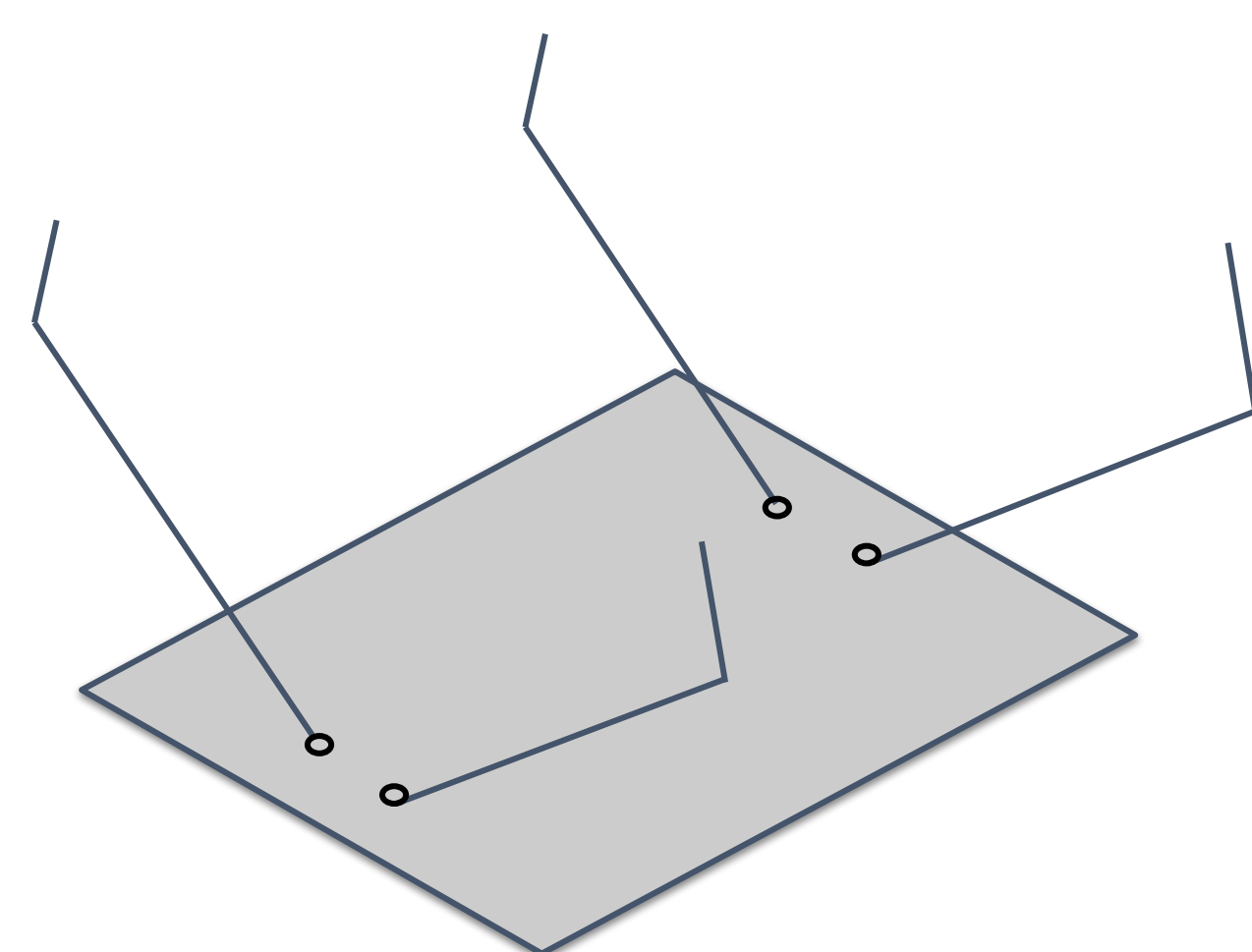


## INTRODUCTION

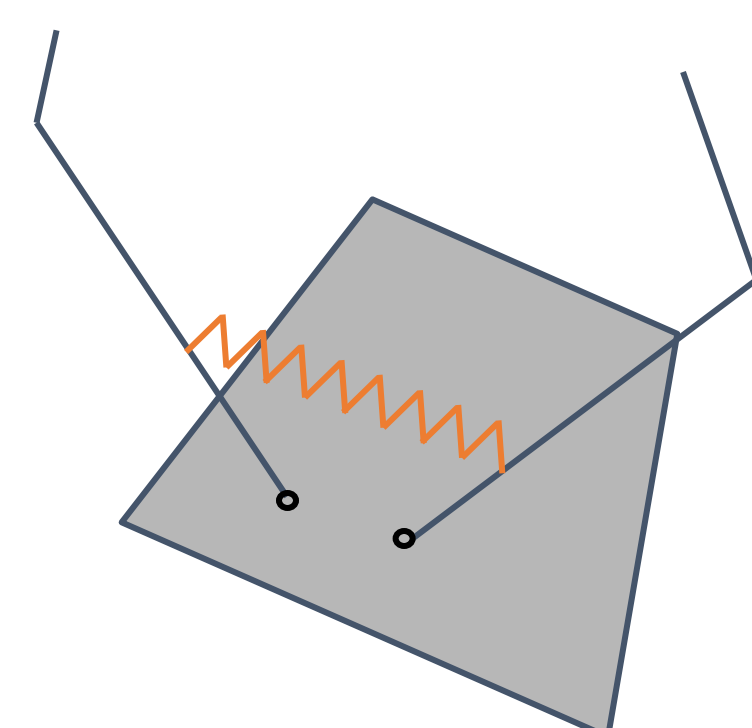
The objective of this study is to develop the clamping mechanism for a hybrid flying and climbing robot that can help bridge inspection especially from under a bridge deck. Current electronic multi-rotor UAVs still have a battery limitation. To extend the robot operation time and make the robot more stable when the sensors are capturing data, a novel design has been proposed to give a UAV four arms on the top that can grasp from under a girder. The challenge of this design is to make the clamping system as light as possible and having all the functions needed for clamping to and traversing under a girder. A series of drive gears are designed inside the clamping arms. A nylon spring mount is designed which can withstand that amount of force while being lightweight and 3D printed. A gear box is designed to move the arm for clamping. The clamping system has been tested to work fine.



Clamping system design

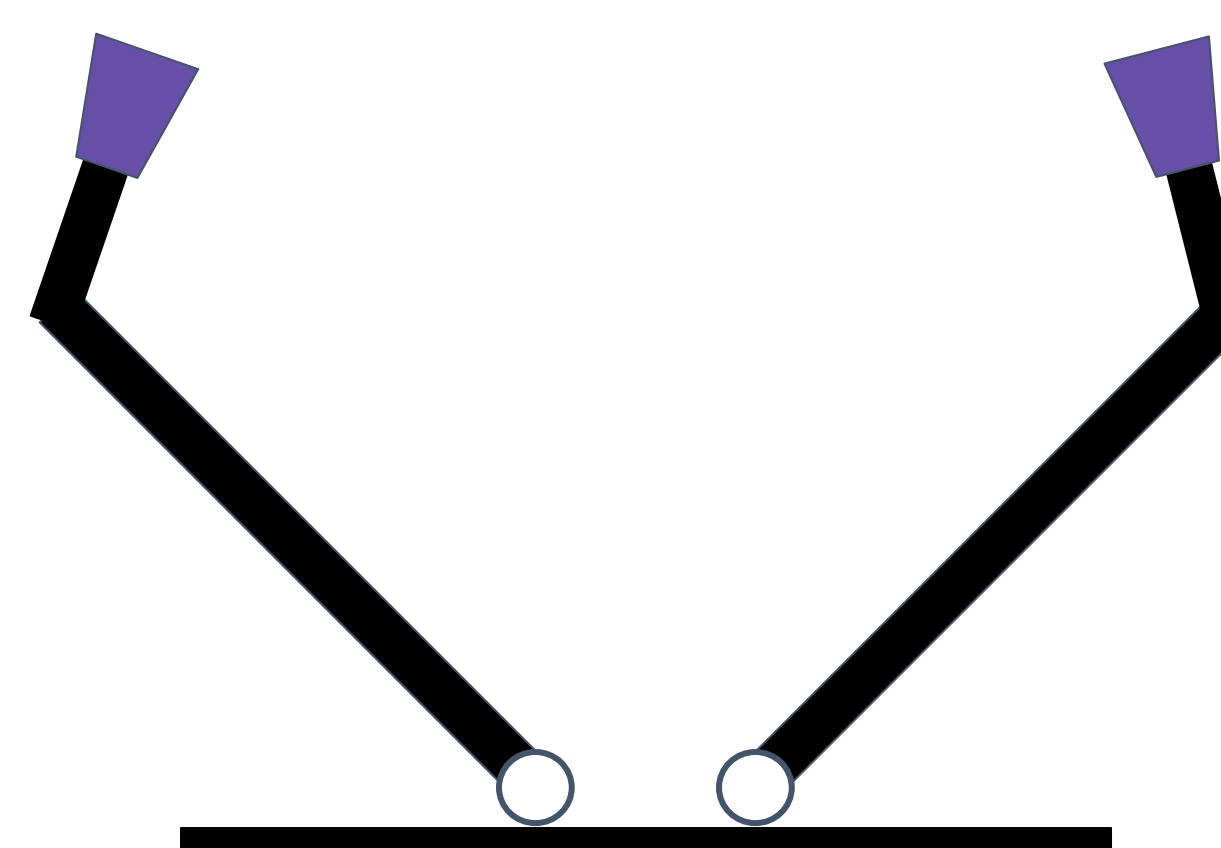
## CLAMPING MECHANISM with PASSIVE FAILSAFE

The clamping mechanism design is challenging because it needs to be light, hold the entire weight of the robot, and fit different sizes of girders used under a bridge deck. To make it safe and reliable, the clamping system is designed to be passive, which means it will keep grasping during electronics failures. A strong spring has been placed between two arms to allow them to close without driving force. One motor under the board provides driving force through two ropes to open the arms when needed. This feature keeps the robot under the girder infinitely allowing plenty of time for a safe recovery.



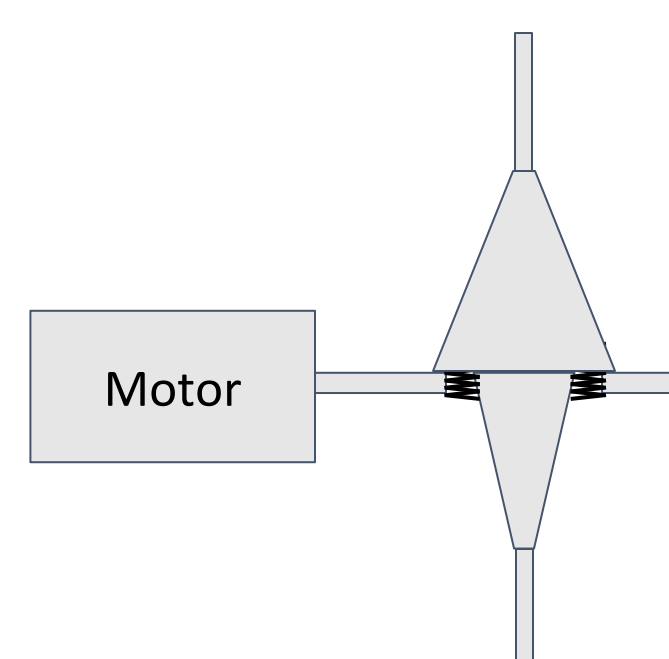
## TRAVERSING SYSTEM DESIGN

The traversing system is responsible for moving the robot along a girder once it has clamped on. The driving force is transmitted through the inside of the arms. The arms change direction at the top to make the end wheel riding on the edge of a girder. Gears are designed to change the shaft directions. A bearing is mounted to let the shaft and gear stay in place when they rotate. The wheel is specially designed to ride on doubler plates and irregularities found on bridge girders.



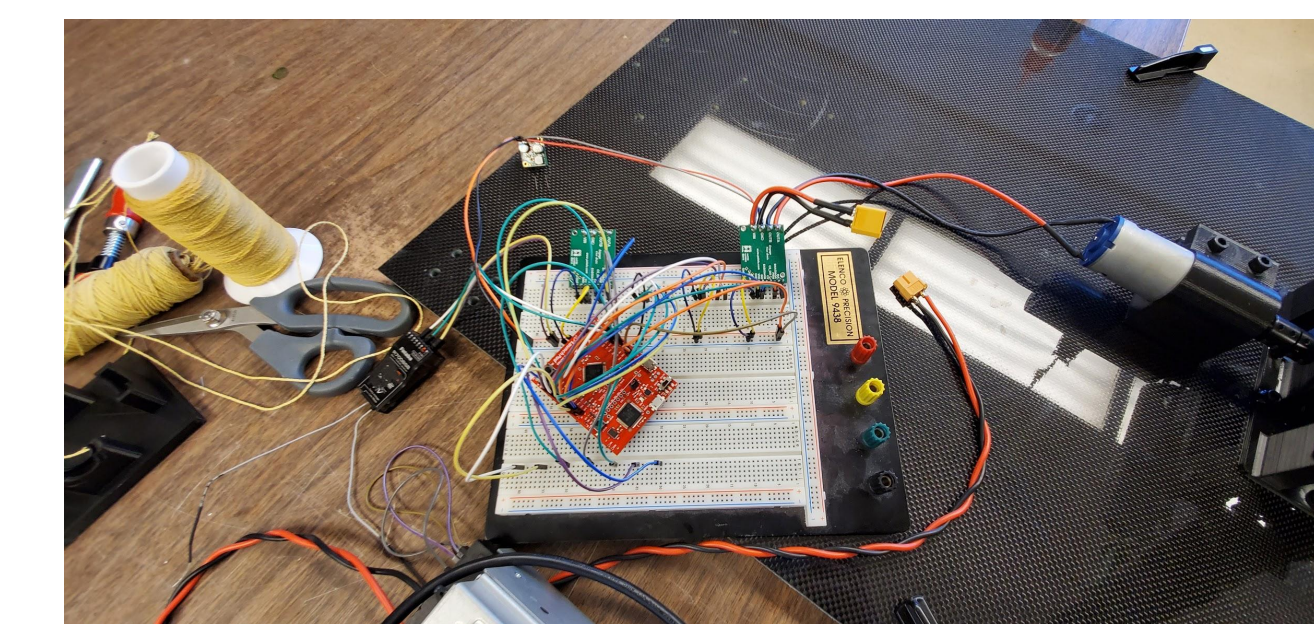
## GEARBOX DESIGN

The driving force for the traversing system comes from one motor on top of the clamping board. A pinion gear (the small gear) drives a crown gear (the bigger gear) to distribute the force into both arms. The movement transmitted inside the arms and goes to the driving wheels. Bearings are fixed to the gearbox to align the gears at the place they need to stay.



## TEST SYSTEM DESIGN AND TEST RESULT

A breadboard is used to build a test system for evaluating the clamping performance. A power adapter is used to convert 110V to 12V. A power module is used to get the voltage needed by the motor and the Tiva C Series Launchpad. A pair of remote controller and receiver is used to send the PWM signal needed to control the motor. The test result shows that the mechanism is able to open and close based on the operation from remote controller.



## CONCLUSIONS

The designed clamping system is much lighter than the previous prototype. The clamping mechanism is tested to work well according to the operation from remote controller. The system is safe and reliable due to the passive design which keeps the arms closed with the force from springs. In the future, the clamping system will be mounted to a quadrotor to implement the whole operation procedure.

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## ACKNOWLEDGEMENTS

Financial support for this INSPIRE UTC project is provided by the U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology (USDOT/OST-R) under Grant No. 69A3551747126 through the INSPIRE University Transportation Center (<http://inspire-utc.mst.edu>) at Missouri University of Science and Technology. The views, opinions, findings and conclusions reflected in this publication are solely those of the authors and do not represent the official policy or position of the USDOT/OST-R, or any State or other entity.