H-AIRFRAME BASED OCTO-ROTOR UNMANNED HELICOPTER

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Abstract

The multi-rotor unmanned helicopters are getting ubiquitous during the past several years due to the advent of new magnetic technologies providing the electric motor industry with high efficiency brushless direct current motors. The applications are endless, but most common use is for camera platforms, research test bed, surveillance, disaster management, military operations, search and rescue operations, etc.

Helicopters with larger number of rotors are generally desired due to their inherent performance benefits and reliability advantage over helicopters with lesser number of rotors.

The current article focuses on eight-rotor helicopters also called octo-rotor machines or octo-copters. Authors compare the contemporary designs while presenting a novel masterpiece of an octo-rotor helicopter based on the H-airframe paradigm.

Keywords: Unmanned multi-rotor helicopter, Multi-rotor helicopter airframe, Quad-rotor helicopter, Octo-rotor helicopter

Introduction

The usage of unmanned aerial vehicles dates long ago to the days of pre-WWII era. All designs were internal combustion engine based, which limited their roles. Recently, due to increased efficiency of electric motors and batteries, users are given the opportunity to acquire unmanned flying vehicles at bearable costs for their projects and everyday experience. Starting from three rotors, nowadays helicopters are almost always using four and higher number of rotors in order to increase reliability. The quad-rotor helicopter has proven to be the simplest to produce and most cost effective, but neither most reliable, nor safest to use. The larger number of rotors guarantees higher safety and better reliability. Thus helicopters with five, six, seven and even more rotors appeared (see Fig. 1).

Authors of the current paper are in development of a series of unmanned helicopters with multiple rotors called the XZ-series. This article presents the development of the octo-copter model XZ-2, which possesses a number of benefits when compared to the contemporary designs.

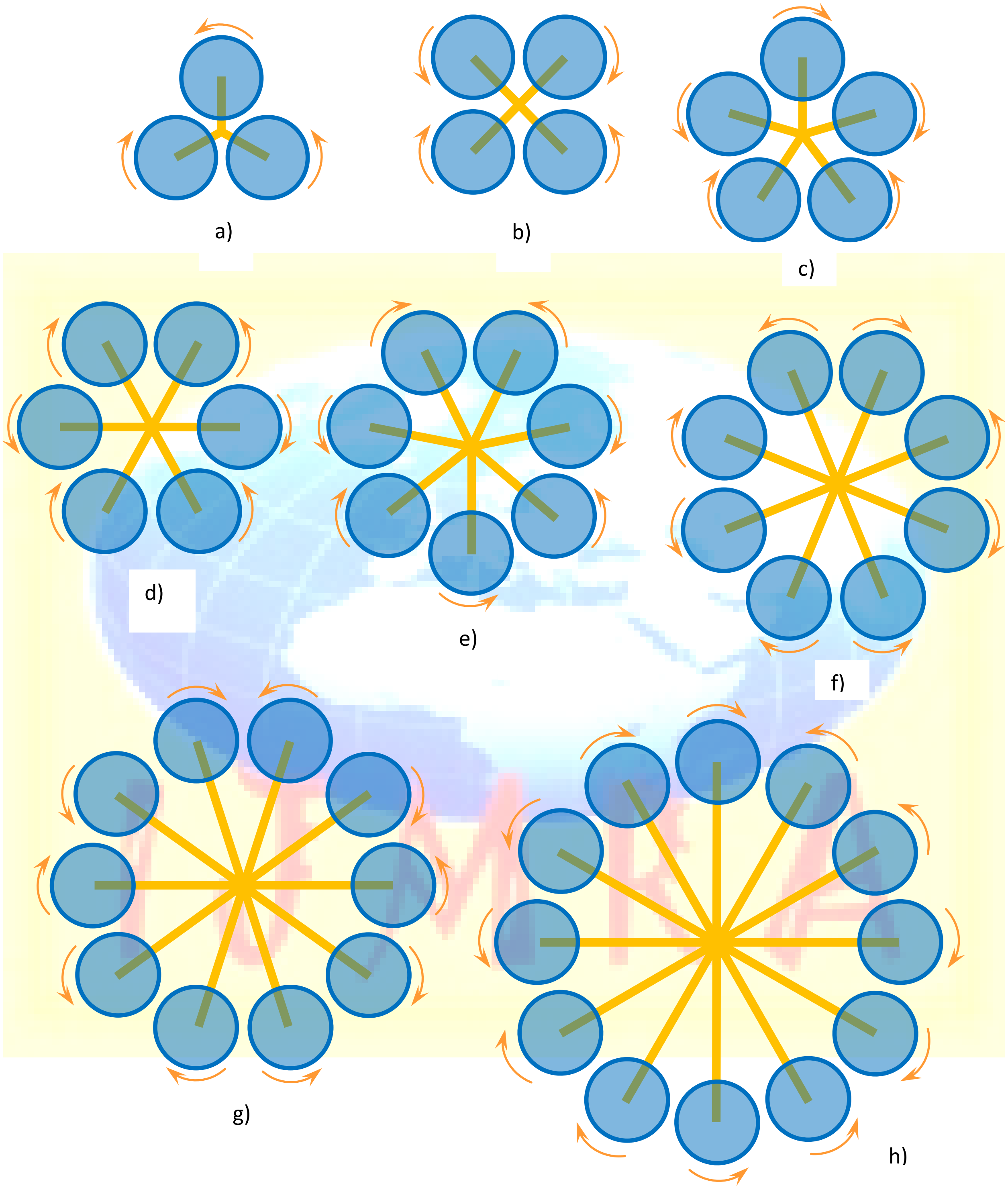

Figure 1. Classic "star"-airframe based multi-rotor helicopters: a) tri-copter; b) quad-copter; c) quint-copter; d) hexa-copter; e) septa-copter; f) octo-copter; g) deca-copter; h) dodeca-copter.

Octo-rotor helicopter designed using the H-airframe paradigm

There are two wide spread configurations of octo-copters. These are shown on Fig. 2. The first construction is based on the “star”-paradigm (Fig. 2 on the left). The second model is constructed around the “square”-assembly (Fig. 2 on the right). While these two airframes have different qualities, octo-rotor helicopters are most wide-spread using the “star”-airframe. Let us observe the differences between these two airframes:

1. What is immediately seen is that the “square”-airframe is more rigid, thus lighter.
2. There are four beams in both designs. Each beam holds a pair of rotors. With the “star”-airframe these two rotors are rotating in the same direction (see Fig. 2). The “square”-configuration implements counter rotation of the rotor pair thus cancelling out the gyroscopic effect of the rotating rotor pair. This is a benefit for the “square”-airframe.
3. Both designs suffer from the lack of fuselage. Mounting of modules and electronic devices is laboured.
4. Camera view is superior in the “square”-airframe octo-copter (see Fig. 3 and 4).

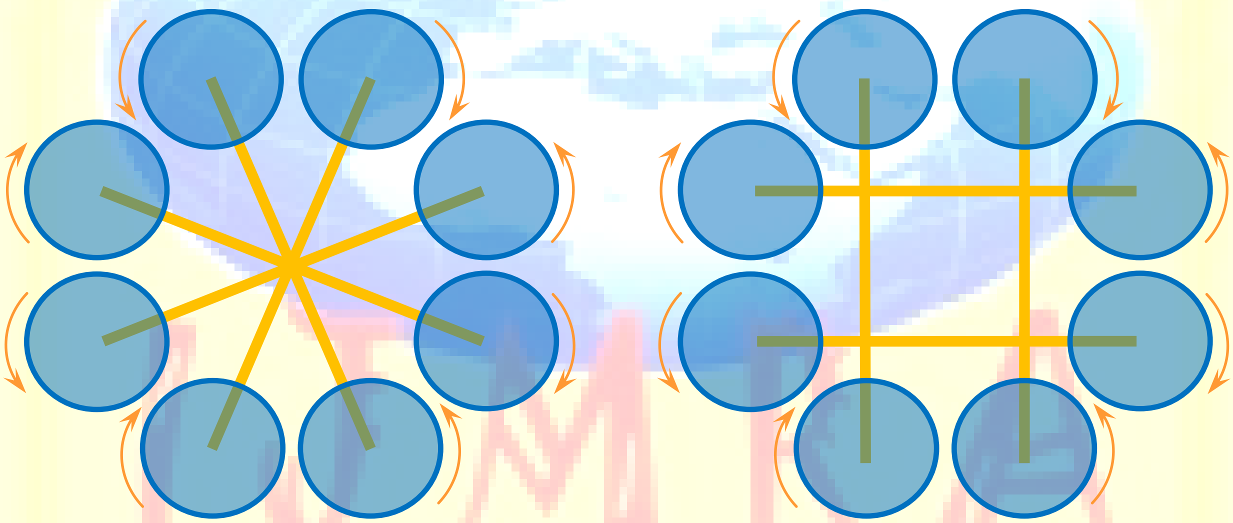

Figure 2. General view of “star”-airframe octo-rotor helicopter (left) and “square”-airframe octo-rotor helicopter (right)

To understand better the rest of the differences between the “star”- and the “square”-airframe eight-rotor helicopters, we should study the yaw manoeuvre. The yaw manoeuvre has proved fruitful for disclosing insights in multi-rotor helicopter features and performance. On Fig. 3 the yaw manoeuvre of the “star”-airframe helicopter is analyzed qualitatively.

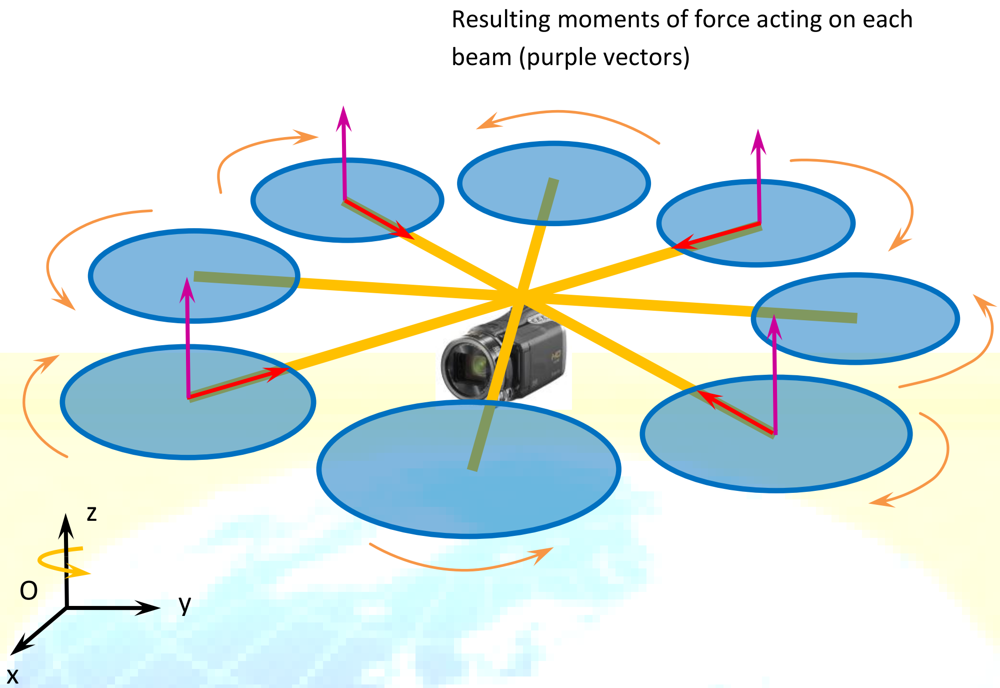

Figure 3. Left yaw turn of a classical "star"-airframe octo-rotor helicopter

During left yaw turn thrust is applied to the right-rotating propellers. This thrust is shown with purple vectors on Fig. 3.

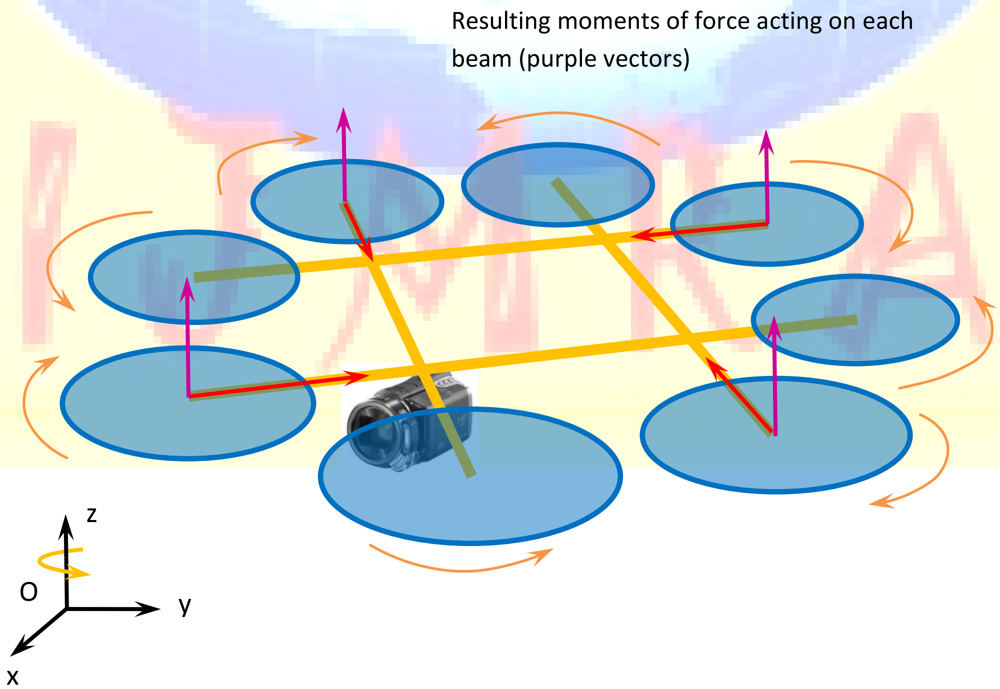

Figure 4. Left yaw turn of a classical "square"-airframe octo-rotor helicopter

The same left yaw turn for the “square”-airframe helicopter is depicted on Fig. 4. The thrust vectors cause bending of the beams thus create horizontal components of the thrust (red vectors), but for the “star”-airframe these cancel out. The presence of beam bending only lowers efficiency of flight and causes no benefit.

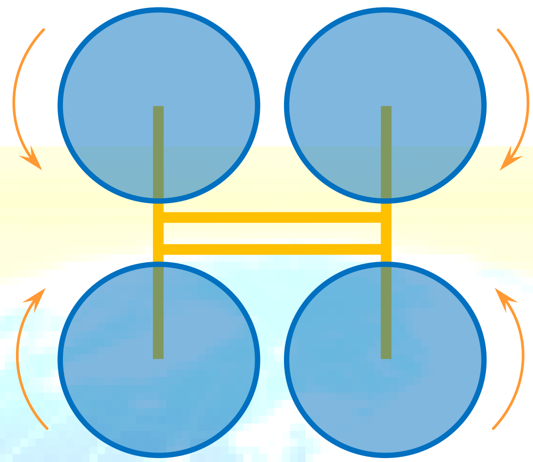

Figure.5. General view of an H-airframe quad-rotor helicopter (model XZ-1)

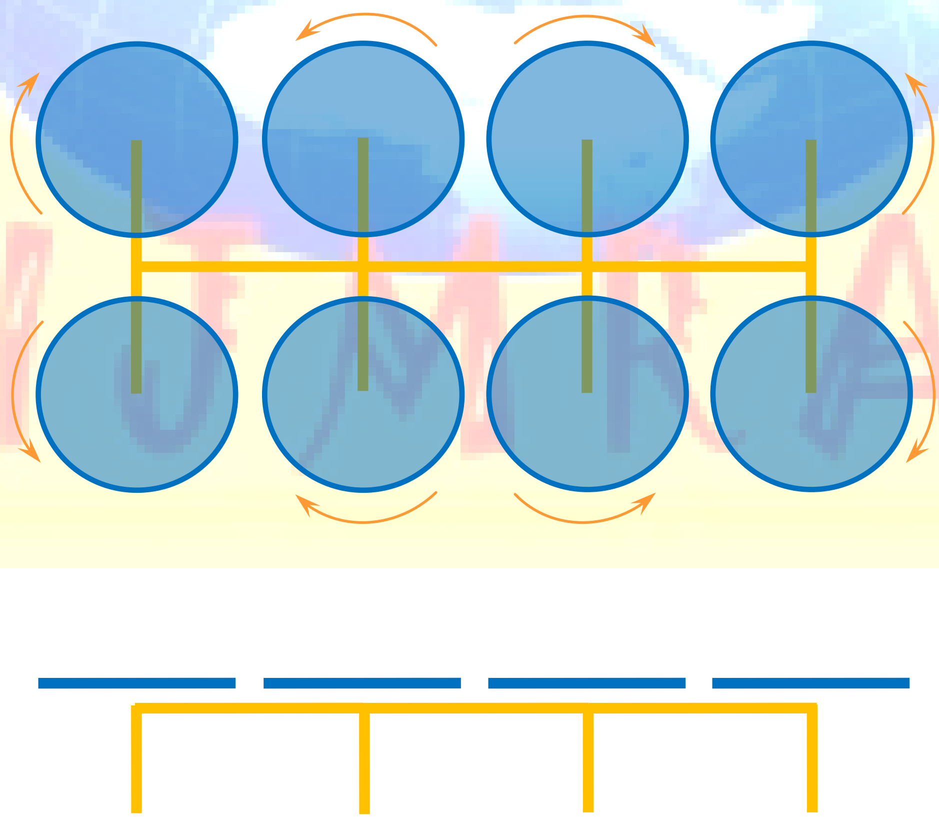

Figure. 6. General view of an H-airframe octo-rotor helicopter (model XZ-2)

In the "square"-airframe helicopter two advantages are visible. Firstly, the bending is lower compared to the "star"-airframe due to the shorter beam length connecting each rotor to the beam cross point with another beam. Secondly, the bending is beneficial, because the resultant torque created by the horizontal thrust components is non-zero and is in the desired direction of the left yaw turn. Efficiency of the yaw motion is higher than with the "star"-airframe.

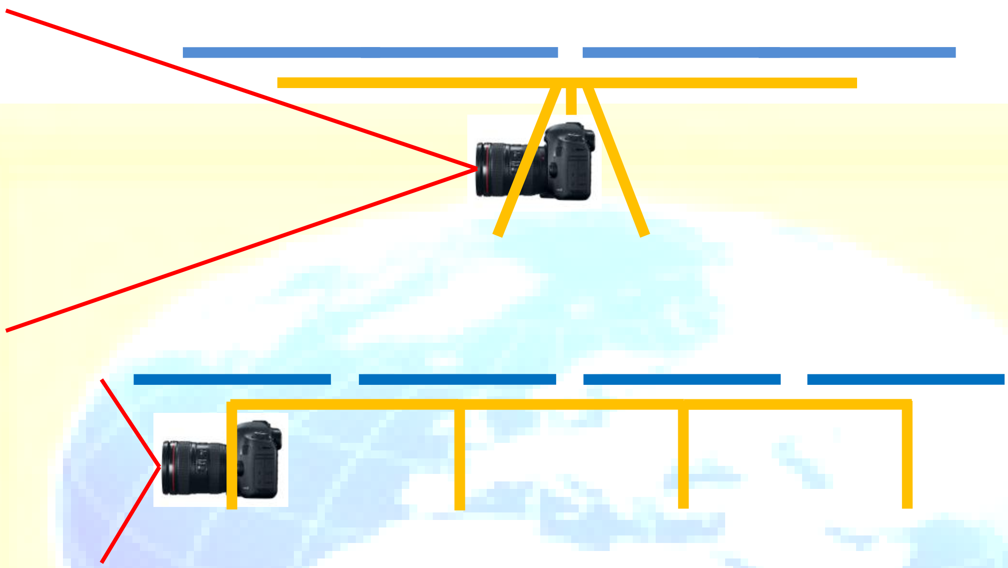

Figure.7. Side view of "star"-airframe octo-rotor (top) and XZ-2 (bottom). The better camera position of XZ-2 is well pronounced.

Having all that said lets investigate what benefits offers the H-airframe of an octo-copter model XZ-2 shown on Fig. 6, 7 and 8.

XZ-2 is based on the H-airframe paradigm used in quad-copter XZ-1 (Fig. 5) of the XZ series multi-rotor helicopters. XZ-2 has fuselage where the user may comfortably install components and equipment. The camera has wide view as it is mounted on one of the ends of the fuselage (Fig. 7). The whole structure has smaller surface thus weighting less and having the ability to pass through tighter obstructions and openings. Further, we will again observe the yaw motion of the novel structure in order to disclose its advantages in detail (see Fig. 8).

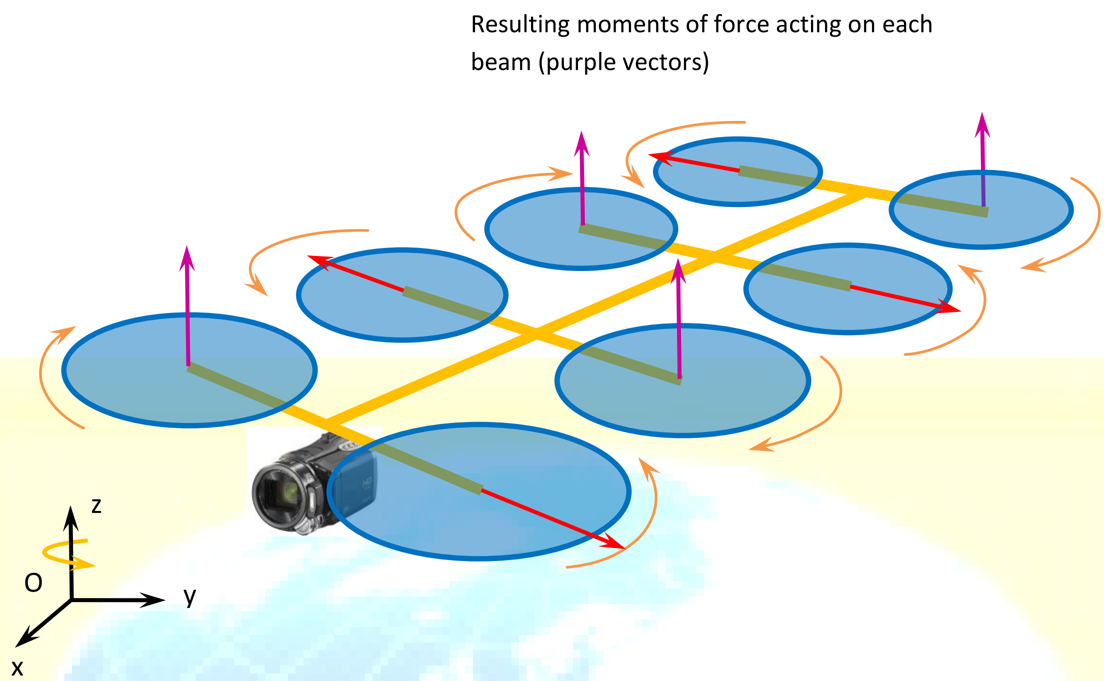

Figure. 8. Left yaw turn of XZ-2

Similarly to the previous octo-copter designs, the H-airframe multi-rotor creates horizontal thrust components (red vectors on Fig. 8). These further establish torques summing to a non-zero resultant torque for the whole structure. Just like with the "square"-airframe helicopter, this torque is in the direction of the yaw turn and is beneficial. The efficiency of the yaw turn manoeuvre is increased.

One further benefit of the H-airframe eight rotor helicopter is its ability to carry two cameras at the two ends of its fuselage with significant distance between them. This setup is suitable for stereo-photography because cameras will be minimally obscured by propellers compared to the other octo-rotor designs and also the two cameras for the left and the right image need to be set wide apart in order to create largest possible parallax. The latter is essential when photographing large areas from a significant distance.

Conclusion

The increasing demand among researchers, government and consumers for more capable designs of multi-rotor helicopters offering better efficiency and lower risk paves the way for novel propositions in multi-rotor design and creates opportunities for the new designs to meet rapid implementation. Octo-rotor unmanned helicopters based on the "star"-airframe structure are full of drawbacks and the revolutionary design disclosed in the present material proves to be considerably superior offering features unattained neither by the "star"-airframe octo-rotors, nor by the "square"-paradigm helicopters.

Authors intend to continue their design work on multi-rotor helicopters based on the H-airframe paradigm as it has proven itself of being a fruitful source of numerous benefit not achieved by the existing constructions.

REFERENCES:

1. Pounds, P., Mahony, R., Corke, P. (December 2006). "Modelling and Control of a Quad-Rotor Robot". In the Proceedings of the Australasian Conference on Robotics and Automation. Auckland, New Zealand.
2. Hoffman, G., Huang, H., Waslander, S.L., Tomlin, C.J. (20–23 August 2007). "Quadrotor Helicopter Flight Dynamics and Control: Theory and Experiment". In the Conference of the American Institute of Aeronautics and Astronautics. Hilton Head, South Carolina.
3. Zabunov, S., P. Getsov and M. Gaydarova. The Rigid Body Motion Table in a Matrix Form. *International Journal of Science and Research*, Volume 3 Issue 7 July 2014
4. Getsov, P., S. Zabunov, G. Mardirossian. H-Airframe Benefits for Constructing Quad-Rotor Unmanned Helicopters. *International Journal of Science and Research*, Volume 3 Issue 8 August 2014