Unmanned Hex-Rotor Helicopter Based on an H-Airframe

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Abstract— Unmanned multi-rotor helicopters are gaining prominence in the past several years among researchers and industry. A notable example of multi-rotor implementation is the cinema industry. The lower cost of using unmanned aerial vehicles (UAVs) for movie making compared to piloted aircraft has promoted multi-rotor helicopters as photographic platforms for professional tasks of filming motion picture and still photographs. Such flying platforms require significantly higher lifting power compared to amateur and hobby UAVs. Further requirements include low vibrations and stability of the helicopter. On account of these characteristics, the most widespread platform for photography is the six-rotor helicopter with "star"-airframe. Simple, yet very productive, it has satisfied to considerable extent the demand by the filming industry and other branches of users. But it still has drawbacks that should be addressed by proposing a newer and innovative airframe design. The current paper presents a new hex-rotor helicopter airframe design based on the H-configuration and compares it with the most widespread "star"-configuration. All benefits in various aspects of efficiency and effectiveness are disclosed.

Key words: Unmanned multi-rotor helicopter, Multi-rotor helicopter airframe, Quad-rotor helicopter, Quint-rotor helicopter

I. INTRODUCTION

The demand from the filming industry for cheap camera platforms yet with excellent photographic qualities has led to the introduction of unmanned aerial vehicles into the cinema avenue. Recently, the advent of high efficiency lightweight brushless electrical motors and high power density batteries made possible the utilization of unmanned multi-rotor helicopters for the purpose of carrying a cinematographic camera onboard. Due to the weight of the filming camera the most prominent representative of the multirotor helicopters, the four rotor machine, proved incapable of carrying this payload in most circumstances. Hence, users have turned to multi-rotors with higher number of propellers. The next suitable step was the six-rotor aircraft or hex-rotor helicopter. The most widespread airframe configuration of the hexa-copters is the "star"-configuration (see Fig. 1). Although capable, this airframe design turns to be plagued with drawbacks thus paving the way to more fit designs of six-rotor unmanned helicopters.

Such a design is disclosed in the current paper. Authors pretend that their airframe design of six-rotor aircraft is superior to the "star"-configuration.

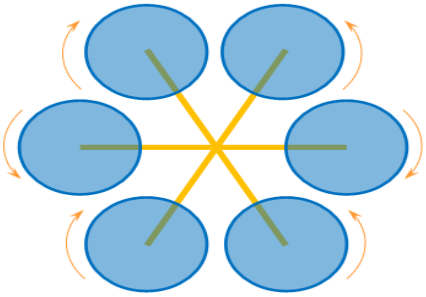

Fig. 1: General view of a "star"-airframe six-rotor helicopter

II. THE H-AIRFRAME BASED HEX-ROTOR HELICOPTER

The "cross"-configuration is ubiquitous among multi-rotor helicopters and is well-known for from the quad-rotor X-airframe helicopter, which is in wide use today (Fig. 2). Evolving from it, the "star"-configuration of hex-rotors was established (Fig. 1) preserving some of the X-frame benefits and drawbacks and originating a few new features. One of the X-airframe quad-rotor design shortcomings is its gyroscopic instability regarding each beam of the airframe (there are two beams). On each beam both propellers are rotating in same direction and cause pronounced gyroscopic effect of the beam as a separate structure (see Fig. 2). This problem is solved with the "star"-configuration of the hex-rotor as seen on Fig. 1, where the tandem propellers on a given beam are counter-rotating.

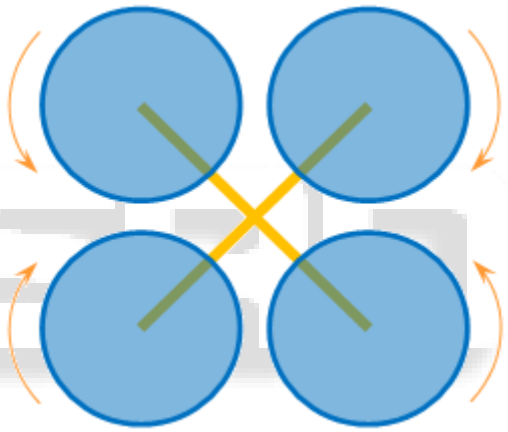

Fig. 2: Classic quad-rotor helicopter in X-configuration

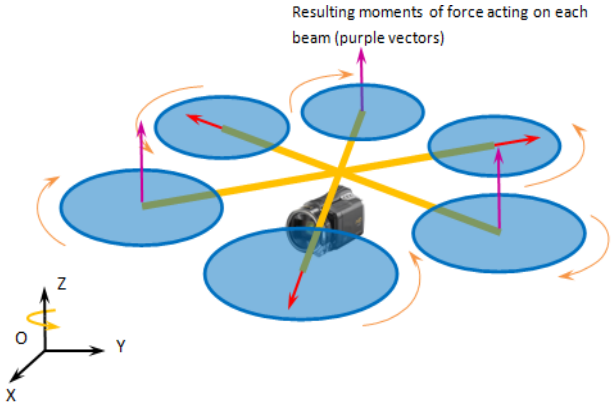

Fig. 3: Left yaw turn of a classical "star"-airframe hex-rotor helicopter

But a new problem arises. Each beam of the hex-rotor design now is longer and less rigid or heavier compared to the X-airframe. Further, when performing yaw turn, as shown on Fig 3, each beam in the "star"-airframe tends to bend against the airframe centre under the thrust needed to perform the yaw motion (see purple vectors on Fig. 3). This effect bends the airframe and vectors the thrusts of the propellers generating horizontal components

of thrust (see red vectors on Fig. 3). These horizontal components cancel out thus lowering the efficiency of yaw orientation change process. A solution to this and other problems of the "star"-configuration for hex-rotors is the H-airframe shown on Fig 5 and 6. This airframe evolves from the H-airframe for quad-rotors (observe Fig 4).

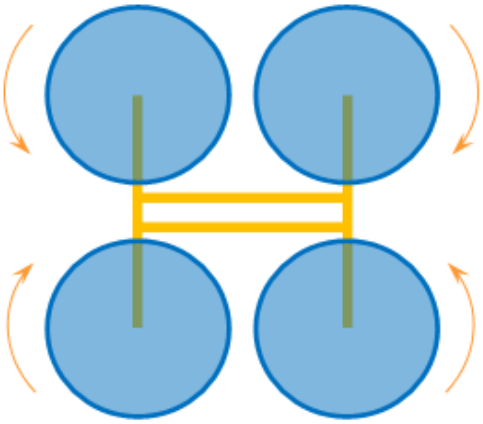

Fig. 4: General view of an H-airframe quad-rotor helicopter (model XZ-1)

Let's analyse same yaw manoeuvre in the H-airframe hex-rotor helicopter presented on Fig 6.

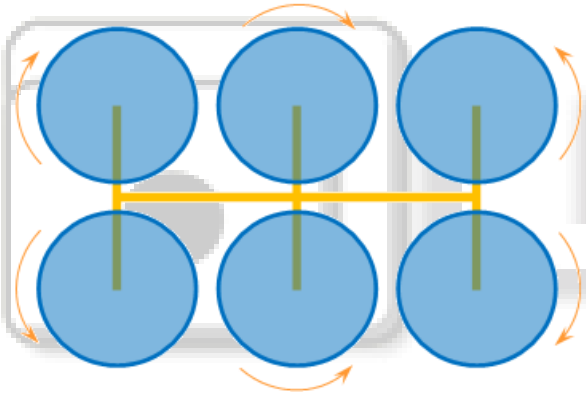

Fig. 5: General view of an H-airframe hex-rotor helicopter (model XZ-5)

At first glance, one would conclude that thrust is delivered by only two instead of three propellers as is with the "star"-airframe and hence the manoeuvre is inefficient, but this is not the case. Again, just like in the "star"-airframe, the H-airframe bends under the yaw thrusts of the two propellers (purple vectors on Fig. 6) and horizontal thrust vectors are generated (red vectors on Fig. 6).

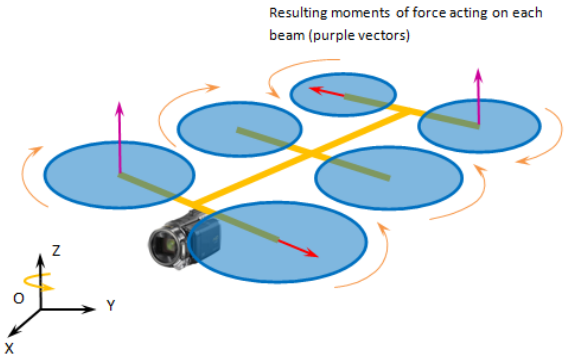

Fig. 6: Left yaw turn of XZ-5

This time the bending of the beams against the fuselage increases the efficiency of the yaw movement instead of decreasing it due to the beneficially vectored thrust caused by the bending of the beams. Red vectors presenting the horizontal components of the vector thrust do not cancel but form a torque in the aimed yaw orientation change direction.

The H-airframe hex-rotor helicopter has even more benefits. These are:

(1) Beams holding the rotors of the airframe are shorter hence lighter.
(2) The camera mounting point is unfavourable in the "star"-construction because propellers obscure camera view (see Fig. 7).
(3) The width of the H-airframe helicopter is smaller thus enabling penetration in cosy openings and manoeuvring through denser grids of obstacles.

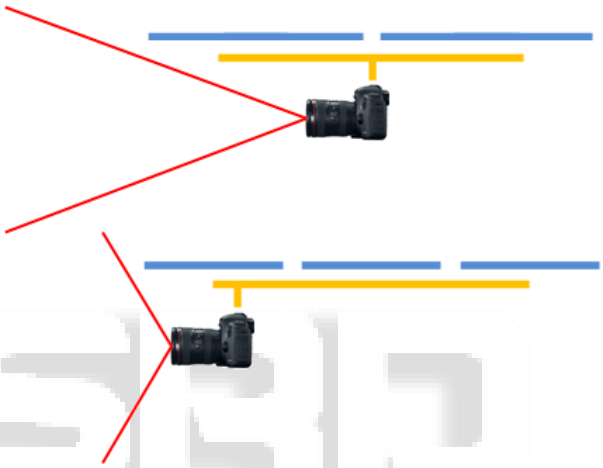

Fig. 7: Side view of "star"-airframe hex-rotor (top) and XZ-5 (bottom). The better camera position of XZ-5 is well pronounced.

III. Conclusion

Hex-rotor unmanned helicopters are gaining prominence in the cinema avenue, but certain drawbacks are restricting their implementation. The current paper presents a new design of a hex-rotor unmanned helicopter that improves on these flaws and reveals new possibilities for the six-rotor helicopter usage.

Authors continue their work on multi-rotor helicopter designs with the aim to improve existing models and create new ones with unattained capabilities by the existing constructions

References

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