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Short Communication

Toward the Light-weighted, Attachable, and Automated Control-enabled Gimbal Design for a Personal Weapon

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Abstract

A gimbal system is a mechanical apparatus that offers multiple degrees of freedom motions. Conventional gimbal motions are roll, pitch, and yaw (3 axes) or pan tilt motions (2 axes) in angles. In applications, these gimbal systems, in conjunction with cameras and other sensors, are used in footage recording for airplanes, helicopters, and UAVs (unmanned air vehicles) or as a handheld device for pictures. These applications are aligned with image tracking, surveillance, or even target tracking and engagement in more industry or military aspects.

Figure 1: 4-axis gyro-stabilized turret from OFIL systems.

Image source: OFIL Systems [1].

Short Communication

An exemplary system is shown in figure 1. This gimbal system is attached to the nose part in helicopters to view, monitor, and track images for operators. Most of the gimbal systems, such as the one shown in figure 1, are 2 DOF (degrees of freedom), such as pan-tilt motions (pitch and yaw) motions [1]. There are some 3 DOF gimbal systems covering all roll-pitch-yaw motions. As a stand-alone system, the gimbal for large vehicles is quite heavy due to multiple actuators and other electronic parts for controls. Highly dexterous 3 DOF gimbal systems commonly equipped for large weapon systems in the deck of battleships are large in volume and heavy [2]

With the advancement of autonomous and unmanned system technologies, enormous efforts to convert conventional, especially personal weapons to automated ones have been investigated recently. Robotic guns or gun-mounted robots also have appeared and been tested for real-world usage to minimize human casualties. However, those systems are also cumbersome and not converted from personal firearms. For example, drones equipped with guns or pistols have not been realized due to the payload. The mechanical gimbal systems to control the firearms are too heavy to be equipped with drones.

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Figure 2: Electro-optics (EO) and infrared (IR) defense weapon system.

Image source: CONTROP Precision Technologies Ltd. [2].

Figure 3: Military drones armed with machine guns [3].

Image source: New Scientist.

The current imaginary drones equipped with guns are shown in figure 3 above. Currently, it is a conceptual design. To operate properly and perform the task-oriented mission, several requirements are expected.

a) Enough payload on drones
b) Sufficient flying time
c) Controllable gimbal design and control systems
d) Light-weighted and highly dexterous mechanical gimbal systems
e) Enabled remote control systems or sensor-based navigation and target engagement features.

This article focuses on mechanical gimbal system designs. Conventional gimbal system designs with either 2 or 3 DOF using motors are not suitable for shock absorption from firing impact and payload capabilities on drones.

It is suggested that the compactly renovated and designed Stewart platform; parallel robotic mechanisms be investigated and tested for this application.

Stewart platforms are parallel robotic mechanism based mechanical apparatus [4,5]. They consist of two plates (bottom and top) and 4~6 linear actuators as they support and connect two plates in between. The length deviation in each actuator's extension and retraction creates unique geometry of top plate. Stewart platforms have 6 DOF and kinematic analysis and related controller designs have been rigorously investigated [6-21].

However, Stewart platforms for target tracking and engagement using personal weapons or converting to wearable devices for battlefield soldiers have not been investigated while enormous demands are sought.

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