Augmented, multi-purpose drone optic-flow odometry sensor with altitude measurement correction

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During the last decade, a noticeable growth in the number of unmanned aerial vehicles sold to unqualified consumer operators occurred. This creates a need for disburdening the user of the UAV from some of the control measures for safety reasons as skies become more crowded. Because of these reasons, aerospace engineers utilize all types of proximity and Time of Flight sensors and their combinations to make aerial vehicles easy to control and collision-proof. Most of the solutions currently available on the market are in the form of an embedded UAV sensor systems with different levels of complexity and different capabilities with no possibility of tuning up. Many drones are also not equipped with some of the sensor utilities. The purpose of this paper is to show the design of the next iteration of a modular, easy-to-use, plug-and-play sensor system that is intended to help the operator of a drone to maintain the intended position during hover.

The sensor design presented in this report was created to return the digital signal with pre-calculated relative position coordinate values which enable the main flight controller to countermeasure the dislocation of a vehicle and hold its position during hovering when the user has no intention of changing the drone position. To achieve that a combination of optic-flow and barometer sensors, connected to an STM-32L011 microcontroller unit platform was chosen. A good graphical representation of which movements the designed device will counteract is shown in figure number 1.

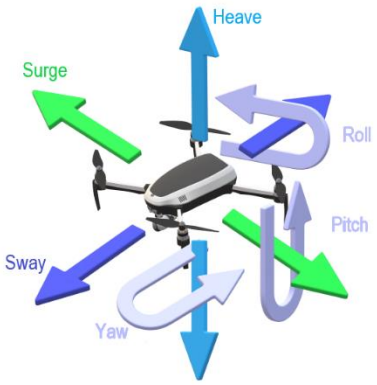

Figure 1: Directions of linear movement which are suppressed by a designed sensor system.

The designed sensor can stop a movement of linear motion in horizontal directions of X and Y axes of the drone on the datum fixed to drone motors thanks to pixels counted by an optic-flow sensor (surge and sway) and vertical motion thanks to the barometer. Optical flow sensors are a wide family of digital movement sensors utilized mainly in fixed positions, in laser/optical PC input devices for instance. The principle of operation of such sensor is the detection of apparent motion of pixel patterns created of

objects, surfaces, and edges and calculating it into the relative distance travelled during movement with digital signal processor unit. In the designed sensor, the built-in barometer also acts as an input for the DSP processor, delivering information about the distance to objects which pixel image was discovered which enables the distance calculations to be exact as these sensors are intended to work in a fixed position to measurement surface as it was stated previously. The working principle of the designed system was shown in figure number 2.

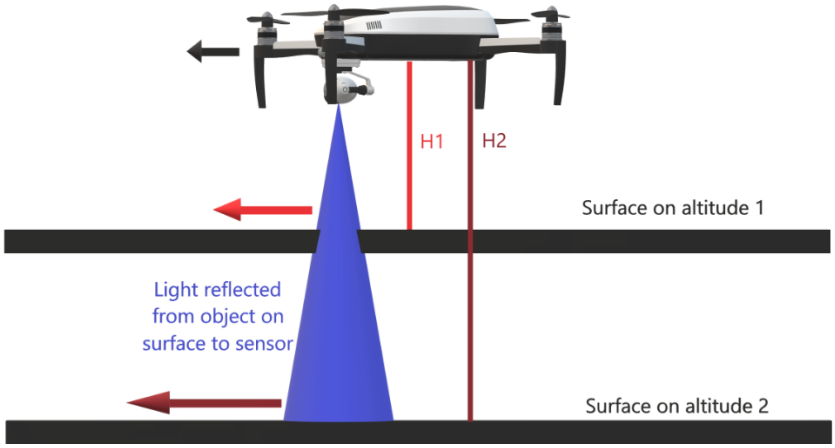

Figure 2: Working principle and field of view size of the optic-flow sensor mounted on UAV.

The introduction of altitude measurement also helps to counteract the optical effects which distance to measurement surface has on an optic-flow sensor such as image size or pixel flow speed. In order to enable the optic-flow sensor available on the market to work on a wide range of distances to the measurement surface a correct lens must be used. Experimental tests have shown that usage of a simple wide-angle lens gives desirable effects. The described sensor system was created with the use of the STM32 platform and SPI protocol to communicate with the external main flight controller. The use of common communication protocol, libraries and APIs enabled it to be tested on popular drone platforms such as PixHawk, ArduCopter, DJI WooKong and Parrot AR Drone.

The system was tested on CC3D, Parrot AR Drone and DJI WooKong platforms. It was checked for a reaction on unintended movement and how its mass and dimensions influence the flight. The designed sensor is a big improvement in comparison to UAV optic flow sensors built by the author previously as it enables to send the exact movement information in relation to flight altitude in a digital form not only information about the movement occurring.

References:

[1] STM32L011x3 Datasheet: “Access line ultra-low-power 32-bit Arm-based Cortex M0+, up to 16KB Flash, 2KB SRAM, 512B EEPROM, ADC MCU”, ST Microelectronics, September 2017.

[2] RM0367 Reference Manual: “Ultra-low-power STM32L0x3 advanced Arm-based 32-bit MCUs”, ST Microelectronics, April 2021.

[3] ADNS-7530 Integrated molded lead-frame DIP Sensor datasheet, Avago Technologies, December 7th 2007.

[4] BMP180 Digital pressure sensor datasheet, Bosch Sensortec, 5th of April 2013.

[5] Devlin J., Ross R. J., Wang, S., “Toward Refocused Optical Mouse sensors for Outdoor Optical Flow Odometry”, IEEE Sensors Journal, June 2012.