APPLICATION NOTE

Autopilot UAV & ROV

Unmanned aviation vehicles (UAVs) are controlled or autonomous drones that performs scouting missions. The drones have various sizes, from a portable unit (SUAV) to a small airplane.

Figure 1: The RQ-11 Dragon Eye (SUAV)

Source from: http://defence.pk/threads/military-uav-designs.119664/

Figure 2: The Predator drone (UAV)

A UAV performs different tasks, including mapping, target tracking, and offensive neutralizing. The UAV has the advantage of flying over medium (30 minutes) to long periods of time (up to 20-30 hours for large unit) without any pilot inside. As a result the drone has 3 critical requirements:

- High stability during take-off, navigation manoeuvers, and landing
- Permanent monitoring - integration of many high performance sensors
- Autonomy – e.g. whenever the command signal from the base is broken
- One of the most important module of the UAV is the autopilot, which allows its remote control. Autopilot integrates sensors corresponding to the 3 above-mentioned requirements. The main functional component of the autopilot is an Inertial Measurement Unit (IMU), composed of 3-axis gyroscopes and 3-axis accelerometers. These two types of sensors are combined to cancel both of their weaknesses. IMUs track the path of the drone, and stabilize its flight whenever the drone operates in windy conditions.

IMUs serves the main functional component of remotely operated vehicles (ROVs). These machines achieve tasks in harsh environments, exploring new abyssal zones, or scouting in a radioactive area, for example. The functions of the IMU here are quite similar to those of the UAV, the only difference is the environments in which vehicles operate.

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Architecture of the Systems

We will focus on professional drones and SUAVs, with a light autopilot system that satisfies the following criteria:

- Auto take-off and landing capabilities
- Waypoint following capabilities
- Relatively low price
- Small dimensions
- GPS aided
- Reliable

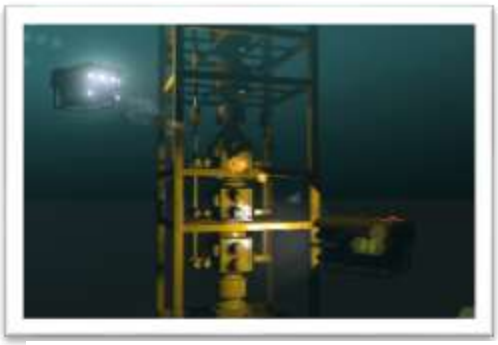

Figure 1: The ROVs can monitor a BOP

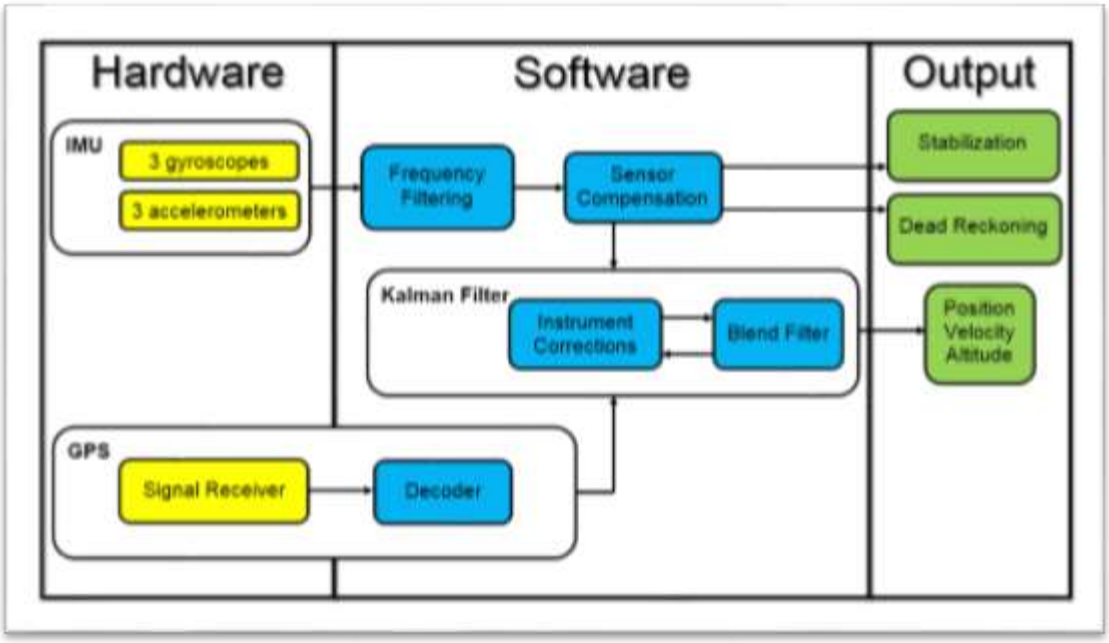

Figure 2: A possible configuration of INS in (S)UAVs

The IMU is a 6 DOF system that measures pitch, roll, yaw, and the mobile in every directions. Therefore, the UAV knows its exact heading thanks to the gyroscopes, and its velocity thanks to the inertial accelerometers.

Environment Analysis

The sensors embedded in a UAV can be exposed to high accelerations and repetitive shocks, during take-off and landing, respectively. In some cases, the IMUs are directly in contact with the outer air. A flying system is based on one crucial point: the lower its weight and power consumption, the longer it flies. Lastly, the drone might encounter crash and can damage its components.
The ROVs working underwater are faced to high pressures. Even if the sensors are fixed into a container, leaks may occur and water can damage the system.

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Required Accelerometer Performance Grades

Any sensor fixed to a SUAV ROV must be light and small, and have a very low power consumption. In addition, high shocks resistance is a key element to keep the integrity of the IMU in case of crash.

In term of accuracy, the IMUs integrated on professional drones correspond to the Tactical or the High End Grade, depending on its dimension and mission. The following table resumes the requirements of these classes[1]:

Class	Accelerometer Technology	Global Bias Accelerometer accuracy	Corresponding Gyro Technology
Tactical Grade	Quatz Servo accelerometer, Vibrating beam, MEMS	1 - 10 mg	, FOG, HRG, MEMS
High End motion control Grade	MEMS	10-100 mg	Vibrating Coriolis, MEMS

MEMS Sensors for UAV & ROV

Decades after its creation, MEMS technology continues to improve in performance. In parallel, SUAVs are reducing in size, demanding even smaller sensors. MEMS capacitive accelerometers follows a simple principle, which relies on a cantilever beam, and on electrostatic charges. If the suspended beam is bended towards an electrode due to an acceleration, the sensor's output will vary. Therefore, voltage and acceleration is related to each other.

Figure 3: The MEMS are massively produced on silicon wafers

The majority of servo balanced accelerometers offer high precision readings, and are the ideal sensors for large, military UAVs that need accurate navigation systems. Nevertheless, their weight, price, and power consumption are not suitable for SUAVs.

[1] Source from http://www.navlab.net/Publications/Introduction_to_Inertial_Navigation.pdf , slide 10

MS1000 – an optimal MEMS acceleromer for UAV & ROV

Safran Colibrys new Open loop MEMS accelerometer MS1000 is specially designed for advanced inertial applications, its +/-2 , +/-5g, +/-10g range will be an optimal sensor for UAV & ROV applications. For example, MS1005 has an initial bias modelling error after compensation with 3rd order polynomial better than 0,35 mg (typ) over a temperature range from -40°C to 85°C and a long term bias repeatability will be 0.7mg (typ) . The sensor current consumption is only 3 mA, which will allow system operation on battery mode. MS1000 accelerometer will continue to deliver Tactical grade measurements even in harsh environments with no major degradation in case of applied shock of 500g and vibration of 20g rms.

Figure 4: MS1000 MEMS Accelerometer

Colibrys makes sure to deliver the best inertial sensors to its customers: the company produces high quality accelerometers that function during decades in aeronautical systems. All sensors are packaged in hermetic ceramic housing, which withstands high shocks and effectively protects the MEMS and the electronics. A self-test function is always available in order to detect internal malfunctions.

Glossary:

- BOP: Blow-out preventer
- CVG: Coriolis vibratory gyroscope
- DC: Direct current
- DOF: Degree of freedom
- FOG Fiber optic gyroscope
- GPS: Global positioning system
- Hz: Hertz
- IMU: Inertial measurement unit
- INS: Inertial navigation system
- MEMS: Microelectromechanical systems
- RLG: Ring laser gyroscope
- ROV: Remotely operated vehicle
- SUAV: Small unmanned aviation vehicle
- UAV: Unmanned aviation vehicle

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