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A prototype of radar-drone system for measuring the surface flow velocity at river sites and discharge estimation

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Discharge estimation at a river site depends on local hydraulic conditions identified by recording water levels. In fact, stage monitoring is straightforward and relatively inexpensive compared with the cost necessary to carry out flow velocity measurements which are, however, limited to low flows and constrained by the accessibility of the site. In this context the mean flow velocity is hard to estimate for high flow, affecting de-facto the reliability of discharge assessment for extreme events. On the other hand, the surface flow velocity can be easily monitored by using radar sensors allowing to achieve a good estimate of discharge by exploiting the entropy theory applied to rivers hydraulic (Chiu,1987). Recently, a growing interest towards the use of Unmanned Aerial Vehicle (UVA), henceforth drone, for topographic applications is observed and considering their capability drones may be of a considerable interest for the hydrological monitoring and in particular for streamflow measurements. With this aim, for the first time, a miniaturized Doppler radar sensor, operating at 24 GHz, will be mounted on a drone to measure the surface flow velocity in rivers. The sensor is constituted by a single-board circuit (i.e. is a fully planar circuits - no waveguides) with the antenna on one side and the front-end electronic on the other side (Alimenti et al., 2007). The antenna has a half-power beam width of less than 10 degrees in the elevation plane and a gain of 13 dBi. The radar is equipped with a monolithic oscillator and transmits a power of about 4 mW at 24 GHz. The sensor is mounted with an inclination of 45 degrees with respect to the drone flying plane and such an angle is considered in recovering the surface speed of the water. The drone is a quadricopter that has more than 30 min, flying time before recharging the battery. Furthermore its flying plan can be scheduled with a suitable software and is executed thanks to the on-board sensors (GPS, accelerometers, altimeter, camera) and artificial intelligence. Finally it has more than 0.3 kg payload that can be used for further instruments. With respect to the conventional approach, that uses radar sensors on fixed locations, the system prototype composed of drone and Doppler radar is more flexible and would allow carrying out velocity measurements obtaining the whole transverse surface velocity profile during high flow and for inaccessible river sites as well. This information represents the boundary condition of the entropy model (Moramarco et al. 2004) able to turn the surface velocity in discharge, known the geometry of the river site. Nowadays the prototype is being implemented and the Doppler radar sensor is tested in a static way, i.e. the flow velocity accuracy is determined in real-case situations by comparing the sensor output with that of conventional instruments. The first flying test is planned shortly in some river sites of Tiber River in central Italy and based on the surface velocity survey the capability of the radar-drone prototype will be tested and the benefit in discharge assessment by using the entropy model will be verified.

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