ASITA 2022

Design, development and testing of a UGV robotic system for mobile photogrammetry

Ettore Potente[1]

[1] Geographisches Institut, Johannes Gutenberg Universität Mainz,
poteetto@uni-mainz.de

Extended abstract

In recent times, the use of unmanned systems has become a key research domain in remote sensing and robotics, thanks to its flexibility and limited costs, which represent the main advantages of these technologies compared to traditional methods.
Starting with a commercial platform, a UGV (Unmanned Ground Vehicle) was developed and tested within a joint industrial and interdisciplinary research project. Its purpose is to perform mobile photogrammetry and infrared surveys, in remote mode, in order to support UAV imagery for accurate 3D modelling in different scenarios. This work briefly introduces the developed system and describes the field tests.
The mobile robotic system utilizes commercial off-the-shelf available hardware and software tools and its development is based on a commercial platform, integrates outdoor GPS and 9 DOF IMU (Gyro/Accelerometer/Compass) for autonomous navigation including a head-mounted display and a game-pad controller. Two sensors have been integrated in the platform: the mobile system is equipped with a RGB and a IRT camera. The open-source desktop software Mission Planner was used to design the missions, defining the waypoints and configuring the autopilot settings for the UGV.

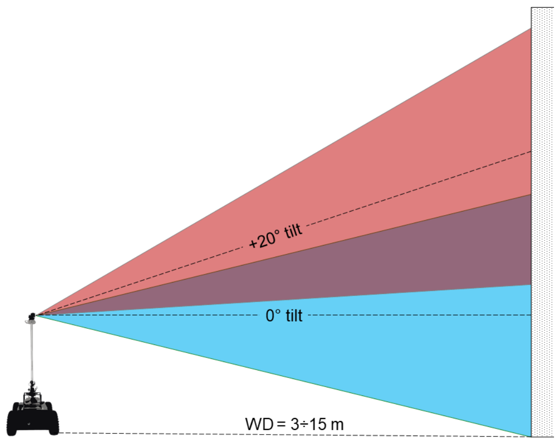

Fig.1. Schematic of the two-camera set-up simulation

Tests were carried out in three different scenarios. In each scenario, imagery from mobile photogrammetric data was collected with the RGB camera, along two-way paths: the camera was mounted on a stand, positioned orthogonal to the direction of movement and to the ground (0° tilt); then, it was tilted upward at an angle ranging from

+10° to +20° in the return paths, simulating a two-camera set-up. Images were collected at every ~1 m, while the robot speed was ~1 m/s in order to ensure a high and adequate overlap between images needed for the photogrammetric processing.
Scenario 1 is an urban site: the pedestrian square Piazza del Ferrarese, (Bari, Italy). It is characterized by the presence of historical buildings and a very slight slope (0.8%) while its surface consists of stone paver blocks. A 22 waypoints (180 meters) mission was planned in this scenario, where the working distance ranged from 6 to 15 meters. The buildings façades were mapped, focusing on the former fish market building, a compact construction on two floors, its architecture is typical of early 19th century buildings, with double ashlar pilasters set on high stone plinths.
Scenario 2 is a natural site, a sandy beach located in the Coastal Dunes Park on the Apulian Adriatic coast (Ostuni, Italy). It is a conservation area, characterized by the presence of a polyphasic dune belt parallel to the coast that reaches an altitude of about 17 m. In this scenario, a 13 waypoints (85 meters) mission was planned, with a working distance approximately ranging from 10 to 13 meters from the main surface.
Scenario 3 is an archaeological site: the dolmen of Chianca (Bisceglie, Italy). It is one of the most important in Europe, dating back to the Middle Bronze Age (1800-1400 B.C.) and consisting of a burial chamber and an access corridor: the chamber is 1.80 m in height and is made up of three large vertical slabs made of limestone over which rests a cover slab that measures 2.40 m x 3.80 m. In this scenario, a 6 waypoints (35 meters) mission was planned, with a working distance ranging from 3 to 5 meters.

The datasets have been processed using the Structure-from-Motion technique and the outcomes consisted in models derived from images (IM) and models derived from video frames (FM). In order to assess the reliability of the results, IM and FM models have been independently compared with reference models (RM), obtained from traditional stationary photogrammetry surveys.
The comparison has been carried out in CloudCompare, using the C2C and local modelling functions. The two models derived for each site (IM, FM) were compared to the corresponding RM by computing the C2C distance between each point of the IM and FM with his nearest neighbour detected on the RM. Mean, standard deviation and RMS were computed for the compared models using the same software.

The study allowed to explore the potential and the limitations of the developed platform as a solution for low-cost terrestrial mobile photogrammetry surveys. The accuracy assessment shows that the C2C mean distance ranges from 1.1 to 1.4 cm for the IM and from 2.3 to 3.3 cm to for the FM.
The combination of mission planning and settings (average speed, time of sampling, geometrical complexity) and datasets characteristics (number of expected, collected and processable images/frames) have been analyzed in order to enlighten strengths and weaknesses of the developed vehicle, as well as pros and cons of this approach. It was also possible to discuss its potential improvements and applications.