iWitnessPRO™ and Wildland Fire Investigation Mapping

Background

Wildland fire investigation involves the examination of fire-related incidents once firefighters have extinguished the fire. The practice is similar to the examination of crime scenes, where evidence is collected and analyzed. The investigation involves surveying the damaged scene to establish the origin of the fire and its probable cause.

Mapping of the burned area is an integral part of wildland fire investigation. Land surveying methods, often restricted to tape measurements alone, have traditionally been used for the mapping. In a hostile post-burn environment, such methods can be slow, manually intensive and error prone.

An attractive alternative approach to fire area mapping is low-cost photogrammetry, a technique whereby 3D measurement and mapping data is derived from photography captured from low-cost, consumer-grade unmanned aerial vehicles (UAVs). Overlapping aerial images captured from a drone are automatically processed by the inexpensive iWitnessPRO photogrammetric software system to yield a digital surface model (DSM) and orthoimage photomosaic of the burned area. In the case study considered here, it was estimated that this aerial mapping method is at least four times as fast and twice as accurate as the alternative tape measurement-based method traditionally employed.

UAV Photography

This case study formed part of a training exercise in La Grande, OR conducted by the Oregon Department of Forestry, assisted by G.L. White & Associates of Bend, OR. A small UAV and iWitnessPRO were used to map the burned area from a training fire. There are two stages to a photogrammetric survey, the recording of photography and the later data processing stage.

The fire area was photographed from a light-weight (300g) DJI Spark UAV. The drone was flown manually via the remote controller's joysticks. Fifty images were acquired of the burn area from a height of 50' in a 12-minute flight. Subsequent photogrammetric processing employed 45 of the images, five being discarded because of the excessive blur caused by the windy conditions. One of the benefits of photogrammetry is that it is a simple matter to record additional imagery to provide good data redundancy and so enhance reliability of the mapping.

To serve as visible ground feature points, the 3D coordinates of which were to be measured, colored flags (blue, yellow, red and white) commonly used in such fire investigations were employed, along with 11 numbered 'evidence marker' placards. Two tape-measured distances, of 10' and 30', served to provide scale for the photogrammetric survey. Red flags represent advancing fire, where the fire is spreading with the highest intensity. Yellow flags represent lateral fire spread, where the fire is spreading with lower intensity, and blue flags represent backing fire where the fire is spreading with the lowest intensity. White flags represent evidence located by investigators. By mapping the spread of a wildfire the investigator can identify the specific origin area and locate evidence of the potential ignition source. On the final diagram advancing fire spread is shown by red arrows, lateral fire spread by yellow triangles, and backing fire spread by blue "U"s.

Photogrammetric Data Processing

The photogrammetric data processing stage involves an importing of the images into the PC-based iWitnessPRO software, after which an automated image orientation and ground point triangulation

phase is carried out. This yields a 3D point cloud of the imaged area, from which both a DSM and an orthoimage mosaic are generated. The orthoimage constitutes a metric quality photo map that supports point, line, polygon and area measurements. Moreover, a photorealistic 3D model of the scene can be generated by overlaying the orthoimage onto the DSM.

As illustrated in Figure 1, the photogrammetric orientation and triangulation phase, the output of which is a 3D point cloud comprising 5888 feature points in this case, took a mere 12 minutes. This was followed by a dense image matching phase in which the orthoimage, shown in Figures 2, and DSM are generated. This final stage of the automated processing, which can also include the generation of a 3D mesh model of the scene, took 6.5 minutes.

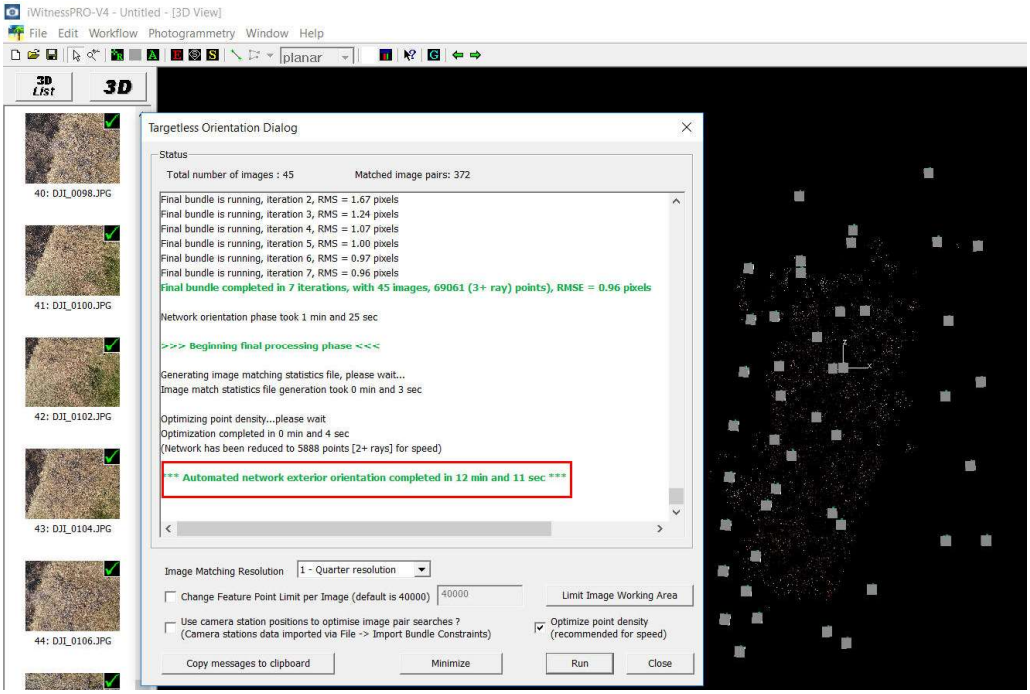

Figure 1: Output summary from iWitnessPRO network orientation and 3D point determination phase.

A straightforward, 5-minute manual operation within iWitnessPRO was then needed to digitize the 3D coordinates of the colored flag points and evidence markers. Thus, all the 3D mapping data needed for both visual and CAD analysis was generated from the recorded photography in under half an hour. The accuracy of 3D ground point determination was better than 1 cm, and as check on the integrity of the photogrammetric network the two scale distances were found to be accurate to fractions of an inch. In regard to CAD diagramming, iWitnessPRO supports export of the 3D point cloud, DSM and orthoimage within either a georeferenced or local coordinate system, in

Figure 2: Orthomosaic of the burned area generated by iWitnessPRO

formats compatible with commonly used CAD software systems. **Figure 3** illustrates a diagram showing the burned area boundary and the positions of flagged points of investigative interest.

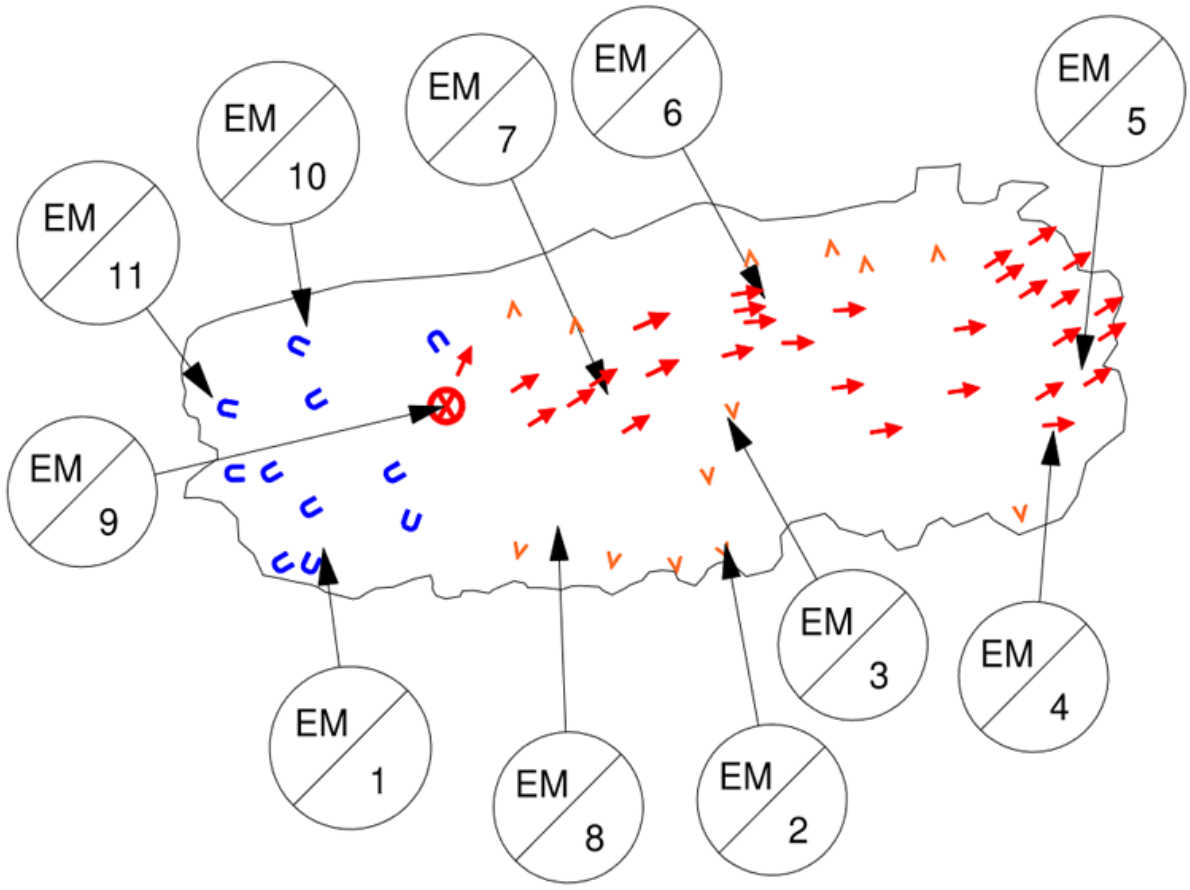

Figure 3: CAD diagramming of burned area

Summary

This case study has illustrated the practical utility of drones combined with the low-cost photogrammetry system iWitnessPRO for wildfire origin area mapping to support wildfire origin and cause investigation. In this case the area was relatively small, but the technique is just as applicable to areas covering 10s of acres, albeit with more suitable drones incorporating larger-format cameras. For such missions, appropriate flight planning and flight control systems are needed. For DJI drones, the inexpensive DJI FlightPlanner and LITCHI control system exemplify what is required to ensure photographs are recorded in a regular strip-wise pattern, with 70 – 80% forward overlap within a strip and around 60% overlap between strips.

The combination of a low-cost (<$500) drone and the iWitnessPRO photogrammetric software system has demonstrated a capability for fast, economical, accurate and highly automated 3D mapping of

wildfire scenes through the generation of DSMs, orthoimage maps and photorealistic 3D mesh models of the scene, coupled with feature point extraction.