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FUELS3D

Annual project report 2017 - 2018

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Cover: Terrestrial laser scanning data being collected for comparison with Fuels3D in Ridgeway, Tasmania.

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ACKNOWLEDGEMENTS

There have been many individuals who have contributed towards the success of Fuels3D at various stages of the project: David Nicholls, Danni Martin, Rachel Bessell, Alex Chen (CFA), Tim Sanders (Melbourne Water), Adam Leavesley, Tony Scherl, Amanda Johnson (ACT Parks and Conservation) and Natasha Schedvin (Vic. Department of Environment, Land, Water and Planning). In particular, Simeon Telfer (SA Department of Environment, Water and Natural Resources) embraced the idea of Fuels3D early on and has provided valuable support, field testing along the way, and practical advice on application of the Overall Fuel Hazard Guide.

EXECUTIVE SUMMARY

Smartphone technology with high quality sensors are becoming increasing ubiquitous. This technology, when combined with computer visions methods allows for the 3D description of the surrounding environment. This project exploits this technology to provide robust measurement of vegetation structural metrics that can be built into existing fuel hazard assessment frameworks. Providing key metrics as data products rather than a single end product enables flexibility across jurisdictions and ecosystem types, and capacity to adapt as end-user requirements change.

Fuels3D is a smartphone app that enables and manages image capture in the field during fuel hazard assessments. 3D point clouds are generated using computer vision and photogrammetry techniques. From the resultant point cloud, representation of vegetation structural metrics such as height and cover can be extracted for use in conjunction with the Victorian Overall Fuel Hazard Assessment Guide, and their equivalents, in assessing the hazard present in a landscape. Fuels3D provides a low cost, easy-to-use, and repeatable method that is currently undergoing field-trials with end-users for assessment.

Highlights of 2017 – 2018 have included:

- Fuels3D adapted for iPhones.
- Two new PhD candidates join the research team (supported by RMIT University funded scholarships, and CSIRO Data61).
- Fuels3D wins the 2017 Victorian Spatial Industries Award for Environment and Sustainability.
- End-user field trials commence in Victoria, South Australia and ACT.

END-USER STATEMENT

Simeon Telfer, *Department of Environment, Water and Natural Resources, SA*

"The Fuels3D project is a perfect example of cross-discipline project which is producing results that have demonstrated improvements to the fire management industry. The project has brought together remote sensing and photogrammetry experts to produce a solution for gathering bushfire fuel data which is faster, more accurate and more informative than previous manual systems. This kind of solution would not have been achievable without collaboration between fire experts within agencies and researchers who have a complementary set of skills and knowledge. "

PRODUCT USER TESTIMONIALS

Rachel Bessell, *Country Fire Authority, VIC*

"At CFA we are excited about the potential of the Fuels3D app. This research will allow us to quickly determine fuel hazard in a more objective and repeatable way. It is very easy to use, taking some photos via a no-fuss app on a smartphone - a technology that is readily available to all of our members. RMIT have involved CFA throughout the project to ensure end user needs are incorporated to support future research utilisation."

INTRODUCTION

Much work exists in developing standards and protocols for describing fuel hazard (for example, "Overall Fuel Hazard Assessment Guide", Victorian Department of Sustainability and Environment) and post-burn severity (for example, "Fire Severity Assessment Guide", Victorian Department of Sustainability and Environment) and their equivalents throughout Australia. The metrics used in these guides have been identified as key drivers of fire risk. However, the methods used to collect these metrics are largely subjective and qualitative, and are limited in their capacity for integration as inputs into fire behaviour models or for use in calibrating and validating landscape level datasets. The next step for these assessments is to include data that is quantitative and has improved precision.

Smartphone technology with high quality sensors are becoming increasing ubiquitous. This technology, when combined with computer visions methods allows for the 3D description of the surrounding environment. This project aims to exploit this technology to provide robust measurement of metrics that can be built into existing fuel hazard assessment frameworks. Providing key metrics as data products rather than a single end product enables flexibility across jurisdictions and ecosystem types, and capacity to adapt as end-user requirements change.

Fuels3D is a smartphone app that enables and manages image capture in the field during fuel hazard assessments. 3D point clouds are generated using computer vision and photogrammetry techniques. From these 3D point clouds, scale is added and decision rules are programmed to calculate quantifiable surface / near-surface metrics that replicate those used in current fuel hazard visual assessment guides. The key steps in the strategy include:

- Agreement by end-users on fuel strata definitions, and new and existing fuel hazard metrics to enable the extraction of metrics from Fuels3D point clouds.
- Field validation of derived fuel metrics will be ongoing as Fuels3D is trialled across a greater number of fuel landscape types (as identified in the draft AFAC Bushfire Fuel Classification System). Fuels3D data will be collected by both the research team and end-users. Terrestrial Laser Scanning, destructive sampling and field measurements will form part of the validation method
- Methods (in-field positioning and image recognition) will be investigated and developed to allow for scaling to be automatically built into the resulting 3D point cloud from which fuel metrics can be derived.
- End-user field trials being conducted to assessment solution usability and performance, and workflow processes.

BACKGROUND

Visual estimation is the standard practice for land management agencies across Australia for collecting fuel hazard assessments. Visual assessment provides a low-cost and efficient method to rapidly describe and estimate fuels and individual fuel layers. However, it is well known and documented in the literature, that visual assessments are subjective and can vary greatly between assessors [1, 2, 3, 4].

In response to understanding the performance of Fuels3D against visual assessments using the Overall Fuel Hazard Assessment Guide, an end-user field day was held with end-users from SA DEWNR, ACT Parks and Wildlife, VIC DELWP, VIC CFA, Melbourne Water and Parks Victoria. The field day aimed to introduce end-users to the Fuels3D collection protocol and to assess its ease of use and repeatability between data collectors in comparison to traditional visual assessment techniques. Participants were asked to undertake a visual assessment and collect Fuels3D data at three plots as shown in Figure 1.

The results, published in *Sensors* in 2017 [4], indicated that surface and near-surface metrics related to fuel hazard can be measured with greater repeatability between different observers. Even more critical was the proprogation of this error when the metrics were combined to calculate hazard ratings. This is demonstrated in Figure 2 where the range of surface cover and height is significantly lower across all plots than seen in the visual assessment approach, spanning across almost four hazard rating classes.

FIGURE 1. EXAMPLES OF THE THREE SITES FROM WHICH PLOT LEVEL FUEL HAZARD ASSESSMENTS WERE COLLECTED BY END USERS.

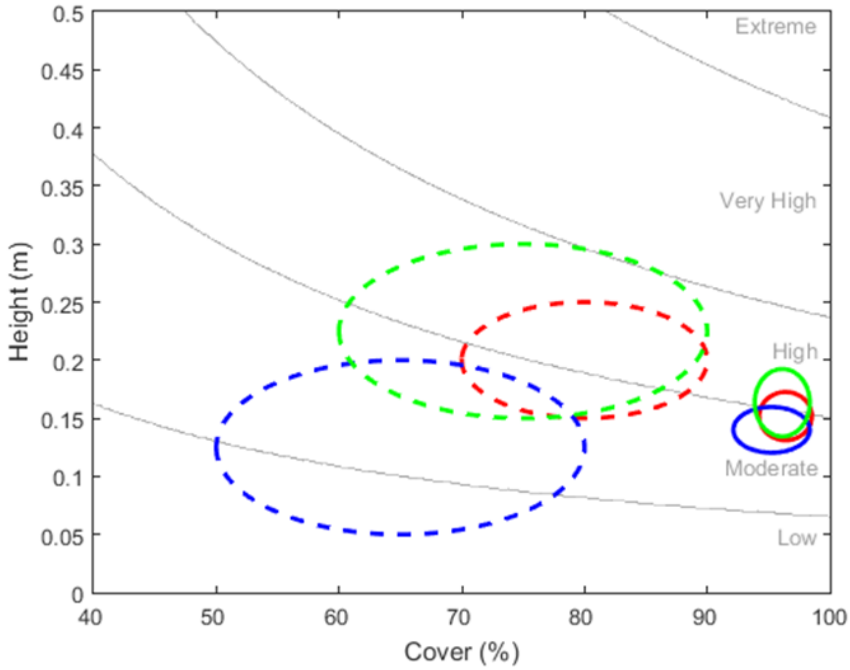

FIGURE 2. RANGE OF SURFACE FUEL HAZARD RATINGS ACROSS THREE PLOTS AS ASSESSED VISUALLY (DASHED LINES) AND USING FUELS3D METICS (SOLID LINES) [4].

RESEARCH APPROACH

The research approach employed for the development of Fuels3D began with a review of remote sensing technologies suited for capturing vegetation structure. Remote sensing, captured from airborne and satellite platforms have long been used as a viable option for characterising vegetation in the landscape. However, estimates of fuel hazard and risk made using remote sensing data still require input at the local, or plot, scale for calibration and validation purposes. Terrestrial remote sensing techniques on the other hand, can provide an alternative or complementary source of information to traditional field assessments and support large scale remote sensing used to quantify and describe vegetation properties.

Terrestrial Laser Scanning (TLS) allows for precise information characterising the amount and structural arrangement of fuel [5] to be collected, otherwise unavailable from visual assessments and large scale remote sensing. However, laser scanning technology remains limited for operational deployment and uptake due to the cost of instrumentation and expertise required to operate scanners in the field. In this project, TLS was used as a comparison for the validation phase of point clouds collected using Fuels3D.

Computer vision and photogrammetric algorithms, which utilise overlapping imagery, are currently being employed in a wide variety of environmental and agricultural applications to provide information describing the 3D structure of the surrounding environment. Unlike other remote sensing techniques, the collection of this information requires relatively low-cost sensors (such as consumer-grade digital cameras) and lower expertise for data collection in comparison to laser scanning technology [6].

Structure from Motion is a technique developed recover 3D geometry from a set of overlapping images and underpins the Fuels3D solution. Common features between images are used to reconstruct the 3D environment. Knowing the locations of several features in multiple images allows estimates of the 3D camera location and 3D point coordinates in relative image-space to be made based on the principles of photogrammetry [7]. The coordinates of camera locations and features are provided in an arbitrary space, which can then be transformed (scaled, rotated and translated) into object (or real-world) coordinates based on a small number of ground control points [7]. In this project, ground control points consisted of unique colour-coded vertical target poles.

Validation of Fuels3D results have been compared against field measures (using intensive point intercept methods), destructive sampling (dry weights correlated to volumetric measures from 3D point clouds) and TLS to determine the accuracy of the solution. Data has been collected across multiple vegetation and fuel types including closed forest, open forest, woodland, low woodland, conifer, hummock grasslands, low shrubland and grasslands (as described in the Draft Bushfire Classification System).

KEY MILESTONES

Key milestones for Fuels3D are summarized according to: development of the app, supporting documents, in-field positioning and scaling targets, and end-user trials.

APP DEVELOPMENT AND DOCUMENTATION

The development of the Fuels3D solution consists of the Fuels3D app, the workflow process and the supporting quick start guides for instructions on the app, the in-field targets and the data collection protocol. In the last 12 months, Fuels3D was adapted for iPhones at the request and support of end-users.

IN-FIELD TARGETS

A key step in creating the 3D representation of the landscape is the addition of scale and orientation to the point cloud. This requires either the camera positions to be known at each exposure (i.e. using GPS) or an object of known dimensions and orientation to be captured within multiple images. For the purposes of Fuels3D the choice of scaling and orientation device needs to be:

- low cost,
- easily portable,
- add no expertise requirements to the infield operation of Fuels3D, and
- accurate enough to allow fine fuel elements to be observed.

Several technologies were reviewed and tested against the criteria of reliability, accuracy, expertise requirements, cost and portability. Those evaluated included stereo imagery, phone sensors, in-field scale bars, ultra-wide band and wireless positioning, and GPS. In brief, both the phone sensors and wireless positioning boards were unsuitable due to low to moderate levels of accuracy. The use of an in-field scale bar was cheap, portable, easy to use and most importantly offered high accuracy for the project requirements. Accordingly an in-field target has been designed for use in the current Fuels3D utilisation trials. This bar uses a unique colour-coded system allowing multiple bars to be placed within the field at any one time (see Figure 3).

FIGURE 3. SCREENSHOT TAKEN FROM FUELS3D ANDROID SHOWING AN EXAMPLE IN-FIELD TARGET IN THE BACKGROUND.

END-USER TRIALS

End-user trials are currently underway in South Australia, Victoria and ACT. End-users have been provided with the Fuels3D app, in-field targets and quick start guides. End-users will collect Fuels3D data and upload the data collected to be processed for point cloud creation and subsequent quality assessment. Any issues with the collection phase by end-users can be reported to an issues log. Results of this first trial will be reported at AFAC 2018.

UTILISATION OUTPUTS

Utilisation outputs consist of:

- Fuels3D app (iphone or android).
- In-field target sets, deployed with Fuels3D apps
- Three quick start guides for using the Fuels3D solution in this first end-user trial (from image capture to image upload).
- Issues register to log any problems encountered by end-users during the trial period.

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