Communicating Smoke Plume Forecasts for Prescribed Burns via Augmented Reality

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[1]CSIRO, Victoria, Australia | ISS3 | April 2020 and updated for AFAC22 August 2022

The imperative to undertake prescribed burning in Australia

In Australia, prescribed burning is used to manage excess fuel loads in fire prone landscapes, with the goal of mitigating the frequency and intensity of dangerous bushfires (wildfires). The potential for bushfires to cause loss of life and catastrophic damage to infrastructure has unfortunately been well evident in the southern and eastern states and territories of Australia during the 2019/2020 fire season[1].

The air pollution impacts of bushfire smoke are significant, with the 2019/2020 fires estimated to cause over 400 deaths due to smoke exposure[2]. Smoke exposure from prescribed burns has also been shown to be harmful to human health[3], and so it is important to manage these burns to minimise the health impacts.

The Australian Bureau of Meteorology assists land agencies, by providing next-day forecasts of smoke from proposed prescribed burns using AQFx, an operational smoke forecasting system[4].

The smoke exposure of every proposed burn is independently tracked, generating a detailed matrix of smoke plume forecasts. The complexity of this information, and the need for rapid interpretation and decision making, often by remotely sited managers, represents a considerable communications challenge.

In this poster, we will explore the concept of communicating this complex information via Augmented Reality (AR) – a computer vision-based technology that superimposes virtual information onto real world objects.

AQFx prescribed burn forecasting

Planned burn teams load scheduler with candidate burns for next day

12 pm

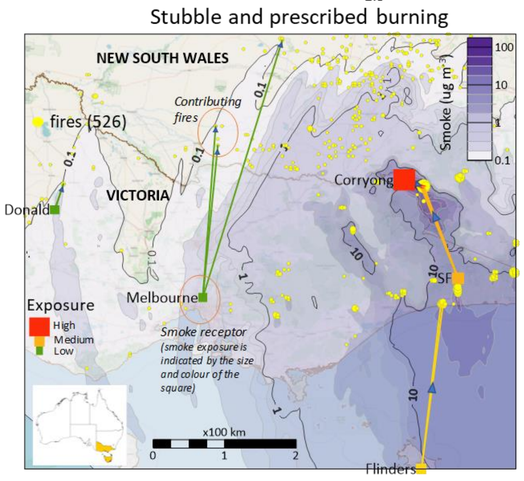
AQFx polls scheduler and runs 24-h smoke forecast
- Fire behaviour and smoke emission forecast
- 24 h tracer transport forecast
  - 2 tracers per fire (flaming; smouldering)
  - 1.6 km grid spacing

1 pm

Prescribed burn smoke forecast delivered to burn planners for short-listing (these fires are then added to an all-source, full chemistry run for 24-72 hour PM2.5 forecast)

4 pm

7th April 2017 24-h $PM_{2.5}$
Stubble and prescribed burning



Development of an augmented reality product for prescribed burn management-considerations

- Simplified visualisation of planned burn smoke impacts (individual and integrated with other sources).
- Ability to manipulate planned burn data in a group situation with remote participants
- Ability to use a variety of devices which are convenient to use off site.
- Highly intuitive interface.
- Question: is 3D visualisation more optimal than 2D for this task?

Example of a coupled UAV and HoloLens 1 wild fire surveillance application developed by Boeing

Preliminary investigation of an AR design using HoloLens 2

The HoloSmoke Project
- smoke plume transport (2D scalar grids over 16 levels)
- wind directions (gridded observations at ground level)
- weather station beacons (point sources of scalar data)
- Himawari 8 satellite imagery overlay

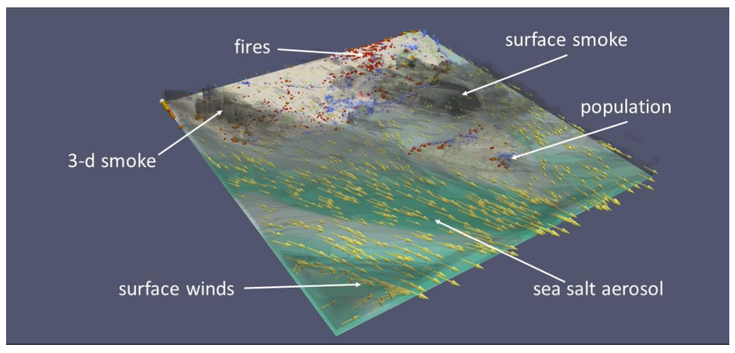
The application supports both gestures and a voice commands interface (video).
It is currently packaged for the Microsoft HoloLens, with potential applications to other VR/AR devices. Challenge- limited storage and processing capacity on the HoloLens 2
Picture credit: https://bit.ly/2VaFwbJ (above right)

Rapid prototyping using generic open-source software

The open-source ParaView package was used to rapidly configure and test 3D visualisations for displaying smoke forecast information.
Positives-
- Natively reads NetCDF file formats
- Intuitive interface
- Python scripting for automation
- Viewable within VR via OpenVR
- Stereo output for viewing (and sharing) on 3D TV/devices

Challenge
- ParaView is not optimised for real-time animation of detailed scenes

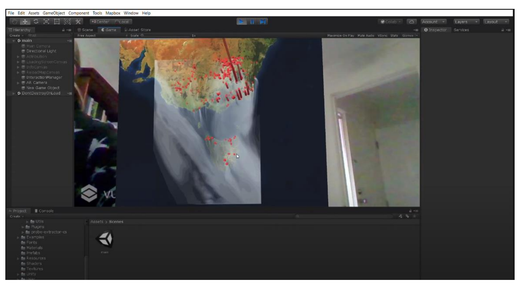
The plot shows a 3D rendering of an AQFx fine particle forecast for 7th April 2017. See here for the animated version of the ParaView rendering.

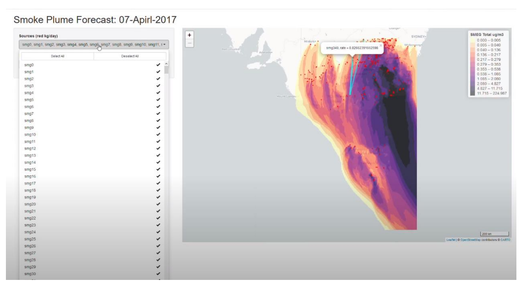


Unity based AR + R Shiny apps for deeper investigation

We use other tools to explore the data:
- The bottom left plot is an image from a video of how our AR app could work on a mobile device.
- The bottom right image (video) demonstrates how we are using an R- Shiny app to explore user interactivity of the forecast data.

These examples are based on the April 2017 planned burn forecast.





Moving to an integrated cloud-based AR system

- The goal is to use HL2 and our forecasts and merge them together, so that the most useful information can be shared across all sites via AR.
- Below we show an early example of the HL2 rendering of an AQFx smoke plume exported from ParaView (video).

FOR FURTHER INFORMATION
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