Mining Google Street View for Urban Climate Micro-Climate Human Thermal Comfort Modelling Parameters

Kerry A. Nice, Jingcheng Wang,
Jasper S. Wijnands, Jason Thompson,
Gideon D.P.A. Aschwanden, Mark Stevenson

Transport, Health, and Urban Design Hub, Faculty of Architecture, Building and Planning, University of Melbourne

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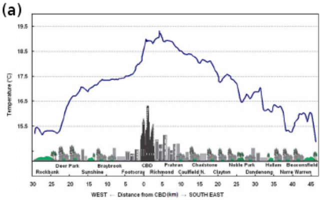
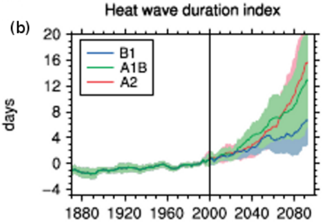
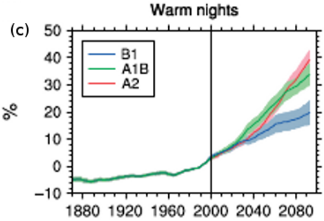
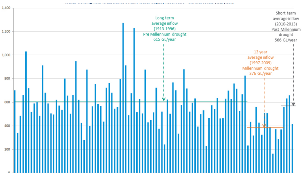
Context - Urban heat, climate trends, water supply





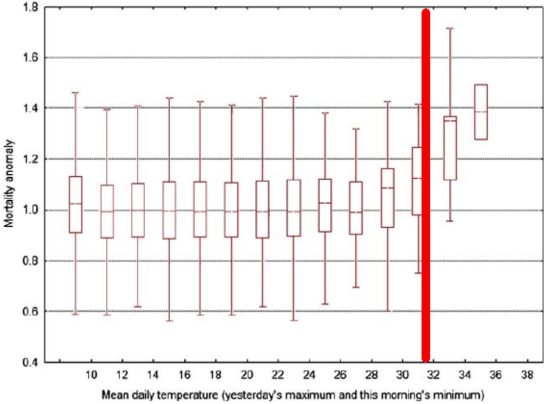




Urban heat island effects; predicted increasing extremes for Australia; Melbourne's water supply

(Coutts et al., 2010; Alexander and Arblaster, J, 2009; Melbourne Water, 2016)

Heat health thresholds

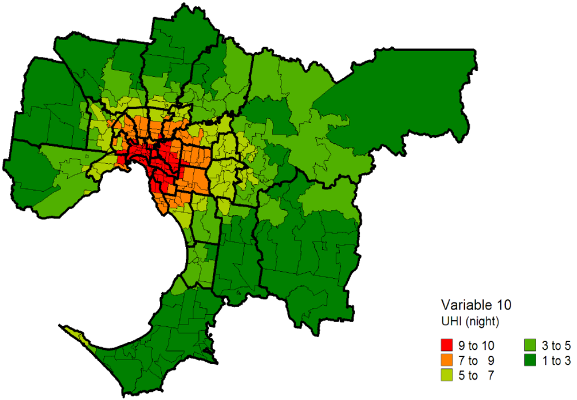


(Nicholls et al., 2008)

Low resolution urban heat data

How to identify priority areas for heat/health interventions?

Variable 10 Urban heat island



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Loughnan et al. (2012)

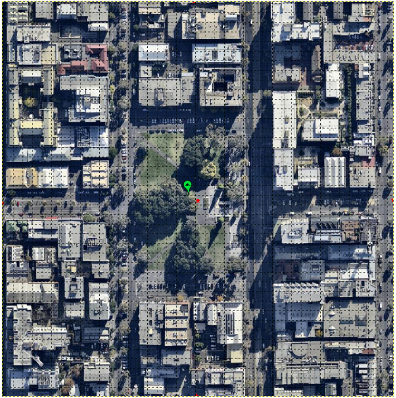
High resolution thermal imagery

Figure 23: Example of road surface temperatures in South Melbourne during the day.

Difficult to obtain at high resolution. Can only make observations of surface temperatures of existing locations at single point in time.

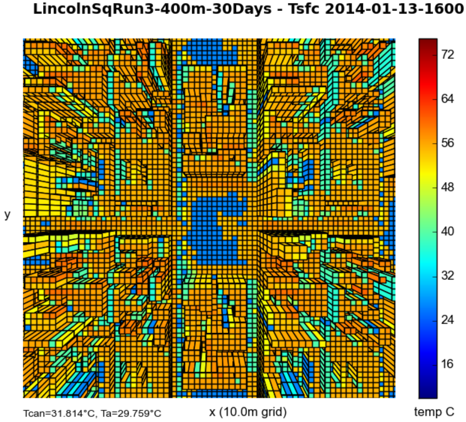
Coutts and Harris (2013)

VTUF-3D, a tool to model the cooling effects of trees at a microscale

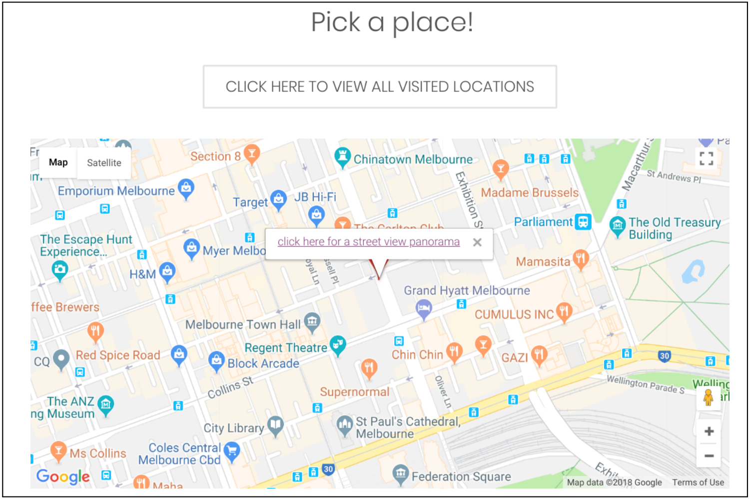


Lincoln Square, Melbourne

(Nice et al., 2018)



And automated / systematic micro-climate modelling.



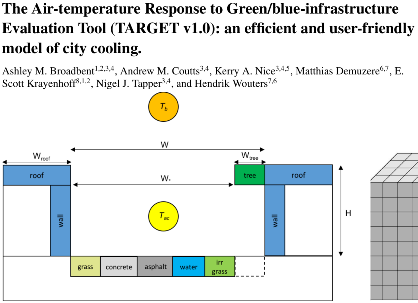
Micro-climate modelling simple enough for non-experts

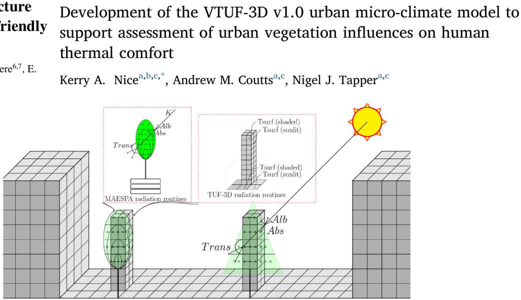
The panorama picture

START

And the modelling begins...

Automated generation of domains for TARGET and VTUF-3D.





TARGET available at:
(Documents) https://mothlight.github.io/target_model/
(Python) https://doi.org/10.5281/zenodo.1300023
or (Java) https://zenodo.org/record/1310138

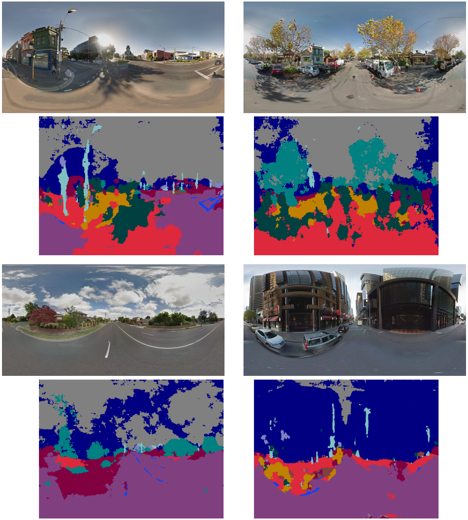
VTUF-3D available at: (Fortran) http://dx.doi.org/10.5281/zenodo.260064 or (Java) https://bitbucket.org/mothlight/vtuf-3d-java.

Urban data

Urban imagery is widely available but how to translate to modelling domains? Necessary parameters: sky view factor, surface types and amounts, building locations/heights, vegetation locations/types.

Classification with convolutional neural network Segnet

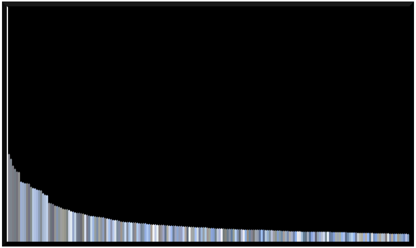
Average results, high training and computational costs



Segnet - Badrinarayanan et al. (2017)

Sky view factor - what color is the sky?

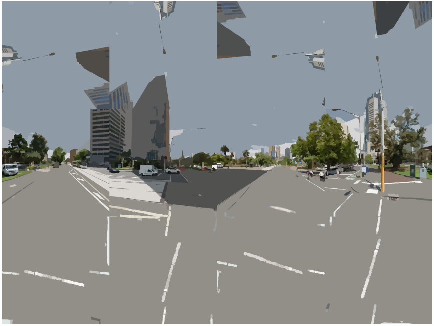
Just pick the blue bit at the top of the image?

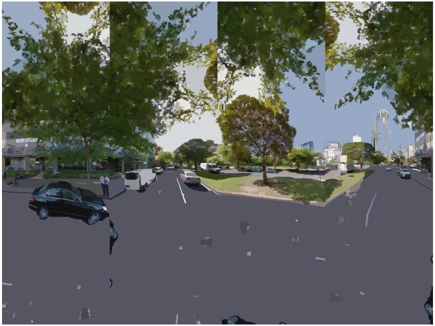


Color distribution of sky calculated from 8894 daytime images.

(Skyfinder dataset - Mihail et al. (2016))

Mean shift





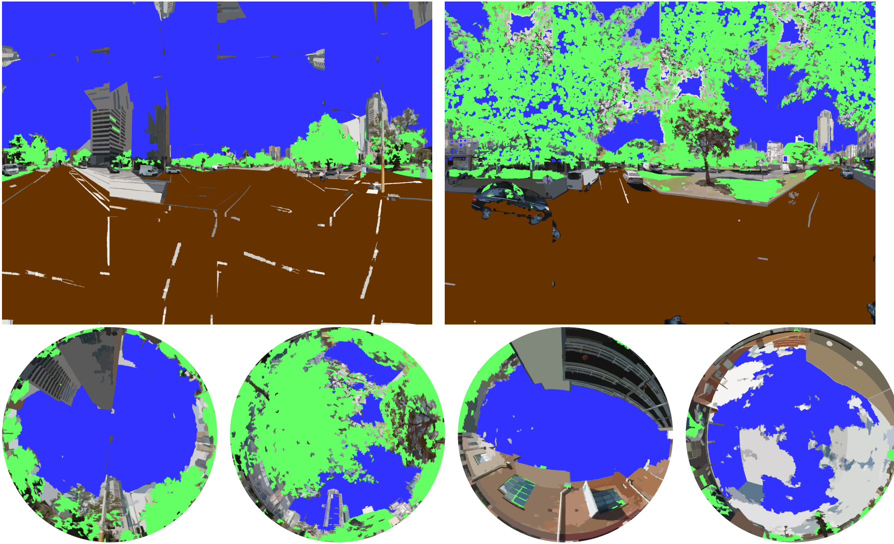
Approach based on mean shift (Comaniciu and Meer, 2002) .
Panels arranged to allow sky colors to flow together. Utilize which colors are above and below image center. Preprocessing step to analyse sky colors and amounts to pick mean shift parameters.

Vegetation

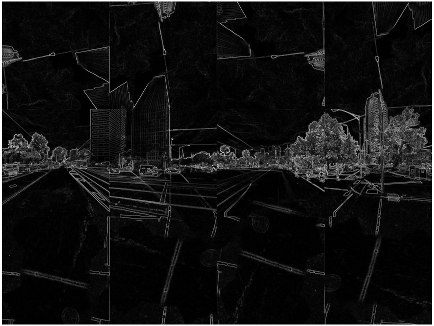
Vegetation detection through Otsu thresholding method.

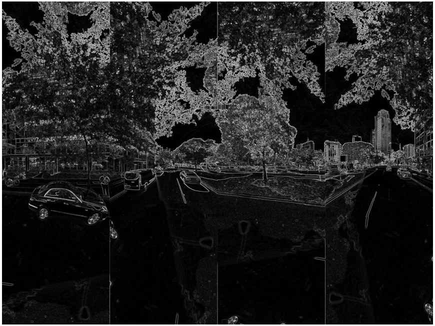
Li et al. (2015)

Output



Edge detection with Sobel filter





Strategies to handle special cases (i.e. high contrast blue/white sky/clouds, sky broken into small pieces by vegetation). Edge detection can be problematic in panoramas as the top of the sky can often contain building/trees, complicating finding a sky border (i.e. Zhijie et al. (2015); Shen and Wang (2013)).

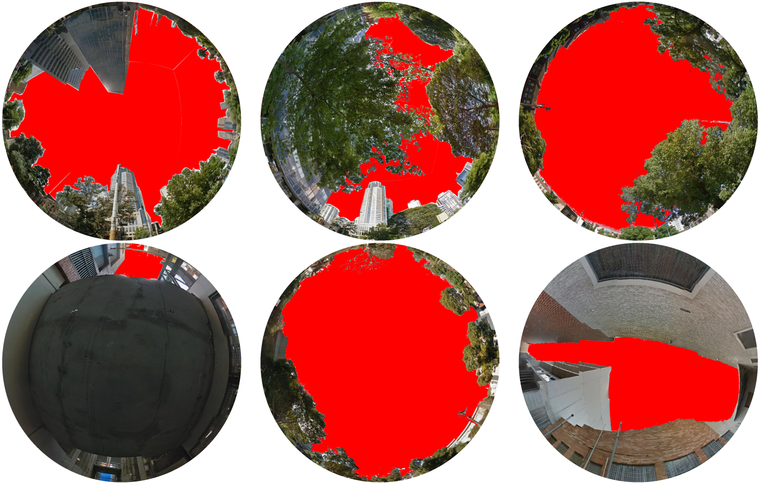
Hough Line Transform and blurring

Strategies to handle special cases (i.e. high contrast blue/white sky/clouds, sky broken into small pieces by vegetation). Find locations of probable non-sky regions.

Canny threshold 1=50, 2=200, Aperture Size=3, Blur size 10x10.

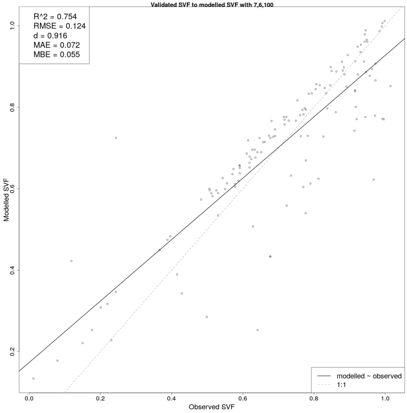
Use preprocessing step (brightness and color distribution) to find and predict special cases and use these techniques instead of mean shift.

Validation



Validation of SVF against hand marked images, using a modified Steyn's method (Steyn, 1980), 36 rings.

Validation metrics

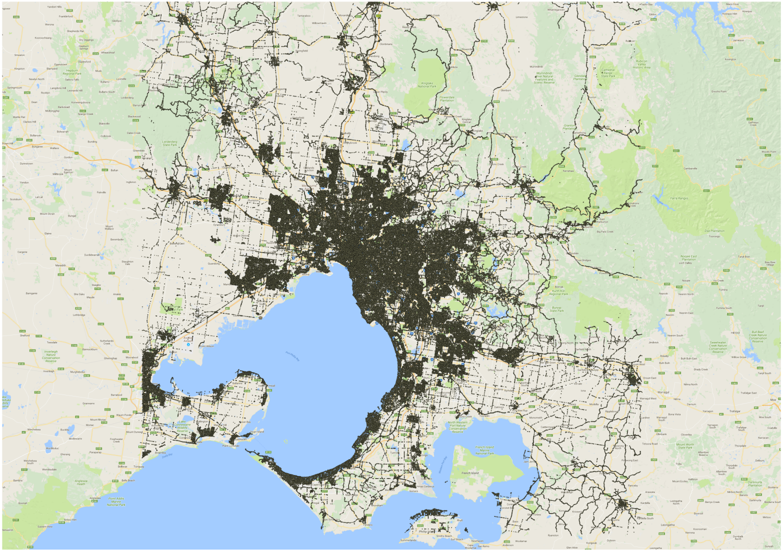


Mean error	0.072
Mean accuracy	0.915
Mean precision	0.938
Mean recall	0.868
RMSE	0.124

Middel et al. (2018) - Validated against CNN classified 98.5% lateral and 99.6% upward facing images. Results: mean SVF difference of 0.002, $R^2=0.880$, and RMSE of 0.045.
Gong et al. (2018) - using CNN classification: Verified by observations- $R^2 > 0.95$, by GIS $R^2=0.40$

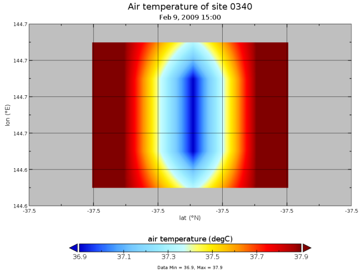
Segnet reports 82-86% global accuracy and 62-81% class accuracy (11 classes) (Badrinarayanan et al., 2017)

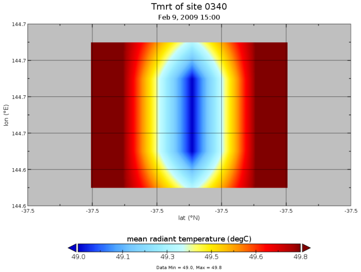
Street view panorama imagery in greater Melbourne

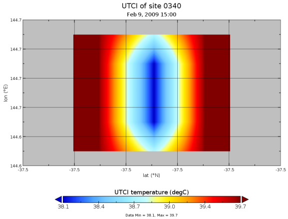


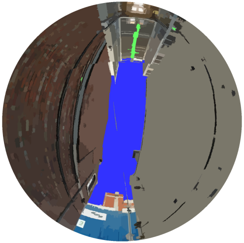
HTC modelling using detected domains

Also using satellite imagery and Open Street Map in future versions.



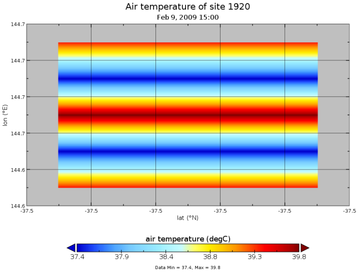


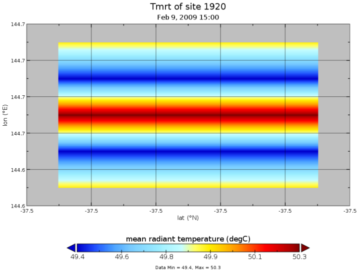


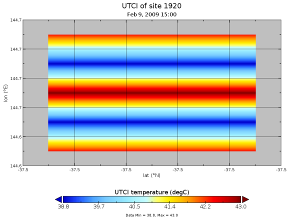


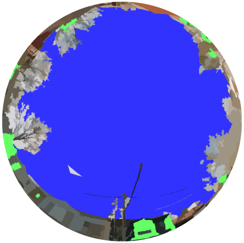
SVF (building and tree locations/heights), green view index, and surface types converted into 25x25m domain and modelled with TARGET (Broadbent et al., 2018) (and VTUF-3D (Nice et al., 2018))

NetCDF results to be combined into city-wide heat map.









SVF (building and tree locations/heights), green view index, and surface types converted into 25x25m domain and modelled with TARGET (Broadbent et al., 2018) (and VTUF-3D (Nice et al., 2018))

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Research team

Transport, Health, and Urban Design (THUD) Research Hub

Dr Kerry Nice (Software Engineer, Urban Climate Modelling)

https://mothlight.github.io/ @mothlight

Jingcheng Wang (Research Assistant)
Dr Jason Thompson (Clinical Psychology)
Dr Jasper Wijnands (Mathematician)
Dr Gideon Aschwanden (Architect, Urban Analytics)
Professor Mark Stevenson (Epidemiologist)
Dr Haifeng Zhao (Complex Systems Modelling)

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