Submission For: ABP Research ECR Project Grant and Graham Treloar Fellowship
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ABP Research ECR Project Grant (and Graham Treloar Fellowship)
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Project Description
Proposed Project Title:
Urban canyon mean radiant temperatures predictions through mining Google Street
View imagery and neural network machine learning

Describe the project, incorporating its aims and background. Detail information
about recent international progress in the field of the research and the
relationship of this proposal to the field generally. Your answer should be no
more than 4500 characters, approximately 700 words including references. Refer
only to refereed papers that are widely available to national and international
research communities.:
Mean radiant temperature (Tmrt), the sum of surrounding surface temperatures, is
the most important parameter in predicting human thermal comfort (HTC) and
thermal stress in urban canyons. Tmrt in city streetscapes is highly influenced
by shading from buildings and urban vegetation, the amount of visible sky (sky
view factor (SVF)), and the types of surfaces and their thermal properties.
However, Tmrt is difficult to measure, and certainly not for arbitrary locations
in a systematic manner.

The focus of this research project will be to allow systematic predictions of
Tmrt in any city streetscape using Google Street View imagery and neural network
machine learning. Methodologies are being developed to extract a green view
index (the amount of green vegetation visible) from street view imagery as well
as extraction of sky view factors from 360 degree panoramas for points along a
streetscape journey within Google Street View. These inputs of urban geometry
will be used along with weather conditions (temperature, wind, and incoming
radiation levels) to train a neural network to make predictions of Tmrt. The
resulting model will then be able to make predictions based on any arbitrary
input of new streetscape location and weather conditions.

Approach
Outline the conceptual framework, design and methods and demonstrate that these
are adequately developed, well integrated and appropriate to the aims of the
project. Your answer should be no more than 3000 characters, approximately 400
words.:
A number of steps will be required to allow a systematic assessment of any given
area. Google Street View panoramas will be obtained through npm extract-
streetview. This imagery will be processed using an ensemble of Segnet image
segmentation classification, OpenCV mean-shift segmentation, and horizon border
detection to classify sky pixels in the image. The image will be converted to a
hemispherical image and sky view factor (SVF) extracted from it. The same
imagery and processing techniques will be used to find a green-view index
(amount of vegetation) as well as a classification of urban surface fractions
for each scene. A neural network will be trained with a large dataset of these
scenes (the parameters of SVF, green-vew, surface fractions, and weather
conditions) and a calculated mean radiant temperature (Tmrt) (calculated through
RayMan or a similar urban climate mode). Once the neural network has been
trained with sufficient scenes, the resulting model will then be capable of
making predictions for any arbitrary panorama imagery and thus can be used to
systematically assess an urban area for heat and thermal comfort performance.

Significance and Innovation
Describe why the research is significant and whether the research addresses an
important problem. Your answer should be no more than 1875 characters,
approximately 250 words.:
Urban heat is a significant health risk, especially during extreme heat days.
Identifying vulnerable areas of cities is a priority for devising effective heat
mitigation strategies. However, making these observations is difficult,
expensive, and time consuming. This project will allow systematic assessments to

be made for any city using a global and consistent dataset (Google Street View imagery).

In addition, the resulting data will be very useful to the urban climate modelling community. Urban parameters such as detailed SVF, surface factions, and amounts of green space are difficult to catalog correctly. Having a method to easily collect this data will help improve the accuracy of urban climate modelling.

Describe how the anticipated outcomes will advance the knowledge base of the discipline and why the project's aims and concepts are novel and innovative. Your answer should be no more than 1125 characters, approximately 150 words.: The project outcome will result in the advancement of the knowledge base in a number of research areas. In the urban climate area, the collection of urban parameters will allow more detailed and accurate modelling domains to be designed. Currently, these parameters are set in an average way by using the local climate zone (LCZ) system to classify urban zone types.

In the urban design area, these techniques will allow urban areas to be quickly scanned for their thermal performance under a variety of weather conditions. This will allow a determination of the health impacts on city-dwellers and to identify vulnerable areas, areas which should be prioritised for remediation.

Detail what new methodologies or technologies will be developed in the course of the project. Your answer should be no more than 1125 characters, approximately 150 words.:
A number of the techniques have been used before, namely image classification and segmentation, in other areas. However, the new methodologies that will be developed during this project are the overall framework and combination of techniques for the aim of determining thermal performance of urban areas. The project will combine a number of image segmentation techniques as an ensemble to best utilise the strengths of each. And the results of these techniques will be carried further, using climate modelling to train a neural network to allow thermal performance predictions to be made using only the input parameters. This will allow detailed urban climate modelling predictions to be made without requiring climate modelling to be done.

Strategic and National Benefit
Referring to the likely impact of this research, describe how the project might result in economic and/or social benefits for Australia. Your answer should be no more than 1875 characters, approximately 250 words.:
The health impacts of urban heat are a large burden to Australia in economic and social terms. As climate change progresses, these impacts and burdens will only continue to grow. Identifying vulnerable and dangerous urban infrastructure needs to be a priority. However, these assessments are difficult, particularly at a wide scale. Having a methodological framework and a tool incorporating these techniques will allow a better understanding of our urban areas and allow them to be redesigned for better thermal comfort and human health.

Explain how the project fits within the Faculty's research strengths or will contribute to the Faculty's strategic research directions. Your answer should be no more than 1125 characters, approximately 150 words.:
As a member of the Transport, Health, and Urban Design (THUD) hub, this project sits directly within two of these research directions. Understanding how urban design impacts human health in cities is a major goal of the hub. In addition, understanding the make up of our cities, in terms of shading, green spaces, and urban surface types is also essential in shifting our transport systems towards healthier and more sustainable modes of transport. Thermal comfort can have a large impact on whether an active transport method is more often chosen over passive modes. This project will allow the data on these urban parameters to be collected and analysed.

Communication of Results
Outline your plans for communicating the results of your research to both your

academic peers and to the broader community. Include possible outlets for publication. Your answer should be no more than 1875 characters, approximately 250 words.:
This research will be communicated in a number of ways. I plan on submitting an abstract to 10th International Conference on Urban Climate (ICUC10) on this work to present it next August. In addition, this work will be submitted as journal articles to journals such as Urban Climate, Urban Planning, or Landscape and Urban Planning. I will likely also write an article for The Conversation about it and disseminate the research through the THUD hub network.

Career Development
Describe how this research project and its outcomes and outputs will support the development of your research career. Your answer should be no more than 1125 characters, approximately 150 words.:
As an ECR, I'm involved in a number of projects as part of our group. However, this is the first project that I will be leading from ideation to delivery. This project has many steps and pulls together a wide variety of techniques from a number of different disciplines. The successful completion of this project will be a major accomplishment and represent a significant contribution to this research area.

Outline the opportunities for future research that might arise from this project. Your answer should be no more than 1125 characters, approximately 150 words.:
This research has many future paths forward as it touches a wide variety of research areas and uses a large suite of analysis techniques. It will facilitate research into urban green spaces. It will assist with understanding the impact of urban design on human health. It is also related to some of the urban typology/machine learning work that our group is currently completing and writing up as a Lancet article. The techniques developed around machine learning, image classification and segmentation will be easily carried forward to future research in this and a wide variety of other research areas.

Indicate what funding opportunities you intend to pursue to further your research in this area. Your answer should be no more than 1125 characters, approximately 150 words.:
This work is also related to an ARC Linkage grant (active transport for school journeys) that our group is just about to submit. Many of the techniques in this project will be able to be reused during the completion of the ARC project. In addition, there is a large community of urban climate modellers (largely using the WRF model) who are very interested in having a method to quickly obtain the types of urban parameters this project will provide. I can foresee possible sources of funding from that sector to further this work.

Budget
Research assistance ($AUD):
$5000

Briefly justify how any research assistance funds will be expended, incorporating the hours and grade of any research assistants to be employed under this project. Please include a consideration of on-costs- casual RA appointments will attract a 15 per cent on-cost to the hourly rate to cover the cost of employment administration and infrastructure costs.:
The only cost to this research will be in research assistance costs. Development and refinement of the techniques in this project will require about 3 weeks of full time (or 6 weeks half time) of work by a research assistant. The RA would need to be of a high grade as Python or Java software coding will be required, as well as some understanding of image processing and machine learning. This work would include some design and coding using the analysis techniques. In addition, they will also need to do a significant amount of testing and refining of the techniques. Many of the techniques used have a number of parameters that can be quite sensitive, requiring time to run and re-run the modelling to find the combinations yielding the best results.

Total requested funds (this section will auto-populate):
5000

Graham Treloar Fellowship
Would you like to be considered for the Graham Treloar Fellowship in 2016?:
Yes
Applicants seeking consideration for the Graham Treloar Fellowship must provide an additional statement below, detailing how the extra funds will enhance the proposed research project. This statement should be no more than 3000 characters, approximately 400 words.:
This project will be enhanced by additional funding in that the extra funding will allow contracting a research assistant for a longer period. This is a somewhat ambitious project, incorporating a number of different disciplines including urban climate modelling, image processing, machine learning, urban design, and thermal comfort. Machine learning, in particular, requires large training datasets to increase predictive accuracy. A large number of climate modelling scenarios will need to be run to properly train the neural network and make the results as applicable to the widest range of world cities and urban layouts.

Also, additional work by a research assistant would be extremely helpful in allowing the methods and framework to be packaged into a friendly user interface, allowing its use by wider user base. This would allow the tool to be used outside an academic research context. Allowing use by organisations such as local councils, consulting firms, and urban design firms will ensure that the knowledge gained through the methods have a better chance of actually being used and implemented in the wider world and applied to real world problems instead of merely being used as an academic research tool.