Multi-objective spatial optimization utilising cloud enabled evolutionary computing

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Abstract
Due to unprecedented climate change, the multitude and magnitude of weather catastrophes has increased at a global level and is expected to continue increasing in the foreseeable future (Monirul & Mirza, 2003). Temperature increases of up to 5°C are expected this century if existing carbon intensive development is not reduced and an increase of existing health disparities including respiratory; heat-related; food-borne; and water-borne illness are also expected to be exacerbated due to the direct and indirect consequences of climate change (Frumkin et al., 2008). Despite this, it is estimated that by 2030 over 5 billion people will reside within cities, however, many urban regions are considered to be situated within high risk locations (Carter, 2011). Additional influences, such as urban heat island and increased impermeable surfaces, may further exacerbate the exposure and vulnerability factors associated with urban populations (Hunt & Watkiss, 2011). Contemporary research has therefore shifted its focus upon assessing the resilient capabilities of urban environments by reviewing current sustainable development practices. Spatial planners are therefore encouraged to adopt robust heuristic methods to determine the best possible solutions required to reduce economic, social and environmental deterioration as a result of expected climatic change (Cao *et al*., 2011).

Multi-objective spatial optimization (MOSO) allows the user to evaluate and compare a wide selection of local optimal solutions whilst simultaneously addressing multiple optimization objectives, therefore allowing complex optimization problems to be assessed (Zhang et al., 2010). Such methods are vital to address the full spatial and temporal dynamics associated with the spatial development of urban environments (Malakzadeh et al., 2010). However, heuristic methods are generally underpinned by complex algorithms and models that are often computationally expensive in terms of their data, RAM and run-time resources. Due to the computational overhead associated with such techniques, it has to date not been possible to scale their application to consider issues such as the temporal evolution of optimized solutions, scaling to larger spatial domains beyond individual conurbations and consideration of very high dimensionality objective optimization.

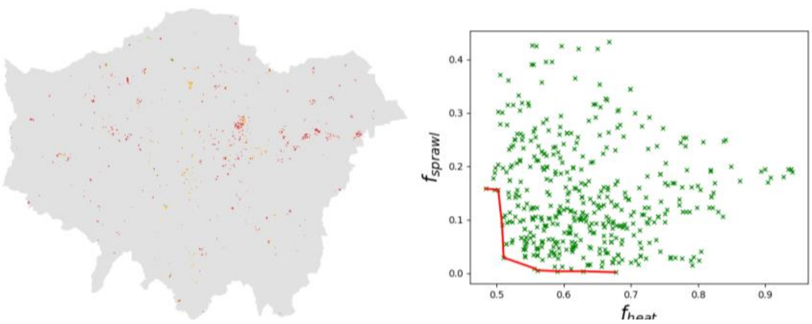

Figure 1 An example of a MOSO framework applied to the Greater London. To the left, a spatial

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development plan and to the right a pareto-optimal set of solutions represented along a pareto-front.

In order to achieve these developments and provide the suite of analytical tools required for spatial planning decision support, it is paramount to couple existing spatial planning tools with new innovations in computing (Ranjan, 2015). By doing so, it becomes feasible to imagine a set of scalable multi-objective spatial optimization approaches that can be used to generate spatial decision support tools that aid the long term development of sustainable planning in the UK that is sensitive to development pressures, urban sustainability and also climate change impacts (Caparros-Midwood et al., 2016).

The ability to apply these techniques at a national level may provide UK planners with sufficient evidence to achieve more optimal spatial-temporal solutions for urban environments. This highlights an appropriate time to explore the abilities of coupling current techniques, such as big data processing frameworks (BDPF's) and Cloud platforms, to investigate the possibility of increasing model dimensionality and/or scale. By doing so, the user may be able to simultaneously assess a variety of sustainability objectives at a national, regional and local level to provide the UK with the next generation of spatio-temporal optimized development plans that account for future climate induced risks as well as sustainability and ecological service objectives. Combining these methods with an analysis of temporal dynamics and their influence upon aspects of sustainable development, such as land-use, would also provide an understanding of the spatio-temporal risk and feedbacks observed within urbanised regions.

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