Creating a national, accurate Digital Surface Model for use on small-scale inter-visibility assessments.

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1. Introduction

1.1 Background

With greater modern computing power it has become common for GIS to be used with increasingly larger study areas when assessing visual impact of proposed developments. Following the introduction of Environmental Impact Assessment (EIA) legislation by the European Economic Council in 1985 and subsequently the European Landscape Convention, visual impact assessment has become mandatory for many forms of development. Whether the site is a proposed new housing development, a wind farm proposal or a new telecommunications mast,) an assessment of visual impact is integral in the decision making process. Typically, there is a requirement to communicate with the public during an EIA and this applies to landscape visual impact assessment. To communicate the likely landscape visual impact of a project to a wider audience, developers often adopt GIS techniques to help understand defined constraints and model how their design fits into the landscape. Hanna (1999) suggests that GIS is actually a fundamental tool within landscape architecture and therefore development projects.

The many analytical techniques used by developers include the viewshed (often referred to as a Zone of Theoretical Visibility (ZTV) or Zone of Visual Impact (ZVI)) and photomontage (also referred to as photowires). Both of these techniques provide insights into the perceived visual impact of a development after its construction. These techniques therefore rely upon either 'bare earth' Digital Terrain Models (DTMs), or more recently Digital Surface Models (DSMs), typically constructed via Light Detection And Ranging (LiDAR) technology or by using derived aerial photography data. As shown in Table 1, in the UK there is an increasing number of DSM and DTM products available for such applications.

Table 1: Characteristics of Digital Surface Model (DSM) and Digital Terrain Model (DTM) data products

Terrain Product	**Model Type**	**Spatial resolution (pixel size)**	**Documented Root Mean Square Error (RMSE)**
SRTM*1	DTM	30m	+/- 18m
OS Panorama*2	DTM	49.6m	+/- 5m
OS Profile*3	DTM	10m	+/- 1.8m
NextMAP*4	DTM	5m	+/- 1m
NextMAP*4	DSM	5m	+/- 1m
Derived Aerial Photography *5	DTM	5m	Up to +/- 0.66m
Derived Aerial Photography*5	DSM	0.5m – 2m	Up to +/- 0.36m
LiDAR*6	Terrain	0.5m – 2m	Up to +/- 0.07m
LiDAR*6	Surface	0.5m – 2m	Up to +/- 0.07m

*1 Harding *et al* (1999) *2 Ordnance Survey (2010) *3 Ordnance Survey (2012) *4 Intermap (2004)
*5 Piperagkas (2009) *6 Montane & Torres (2006)

1.1 Need for a small-scale DSM

With a small development site (for example a small-scale housing development on an old brownfield site) commercially available DSMs are often suitable, albeit relatively expensive. However, for projects whose visual impact may extend over a larger area, the use of DSMs becomes impractical due to both resolution and cost.

A prime example of this is within wind farm ZTV analysis. These projects often involve structures around 100m high (there have been assessments of some sites at 200m to their blade tips) and a study area of around 40km radius (as defined by University of Newcastle 2002). This means that the ZTV analysis needed to be undertaken on an area exceeding 16,000km^2. With a traditional "low" resolution digital surface model of 2m^2 this would equate to around 8,000,000,000 data points and (if using the cheaper derived aerial photography rather than LiDAR) a commercial cost of around £21,500 (considering the digital data would also have to be purchased at a cost of around £16,500, this means this analysis would cost roughly £40,000 per project). Aside from costs, the processing power and time in calculating a ZTV make this level of detail impractical for most small scale GIS work. Given this context, the need for a modestly priced, generalised DSM for small-scale applications is clear. Traditionally these "models" have been developed using sketched urban and woodland blocks and other vector areas depicting landscape objects, to which heights can then be assigned. With the advent of Ordnance Survey (OS) OpenData, the availability at no cost of Meridian and VectorMap District building and woodland polygons have allowed construction of more accurate obstruction footprints. However, estimating object Z values remains problematic. By convention, the industry currently uses standardised heights of 15m for all woodland blocks and 7.5m for all buildings. Although these heights are widely accepted as standardised approximations they can lead to both false positive and false negative results in the resultant ZTV. In 3D urban analysis, the impact of assuming a standard building height is even more extreme. Newham (2011) describes how building heights in the Stratford area of London differ wildly from two and three storey terraces up to 20 storey tower blocks, suggesting current models based on a standard building height of 7.5m would not reflect the actual cityscape.

Therefore, as part of the EIA process, the development industry requires a mid-resolution DSM to help interrogate and understand how physical obstructions (e.g. woodland or buildings) can obscure proposed development sites.

2. Proposed Approach

With DTMs the solution is simple (and was undertaken by Ordnance Survey with the creation of Landform Panorama (Ordnance Survey, 2010) with a basic resampling technique to convert their detailed model into a coarser product. However, after resampling high resolution DSMs by aggregating and averaging pixel values, the obstructions would become lower but the terrain around these features would rise, potentially affecting overall accuracy of ZTV output derived from any resultant output moderate resolution DSM. For ZTV analysis the ability to compare surface and terrain products to ascertain the obstructions (and therefore any false positives in the analysis (Lock, 2012)) means that the final product would also have to be closely linked to a similar DTM. The proposed mid-resolution product will only have heights around every 30m as an enhancement to the freely available OS Panorama but at a cost acceptable to projects covering large study areas. Smaller features (such as single trees and hedges not mapped by OS Open Data) will have to be excluded from the mid-resolution Digital Surface model. Therefore, by generalising from the NextMAP terrain and surface products and combining these with OS Opendata's Vectormap District Urban and Woodland features, it is hoped that complementary mid-resolution surface, terrain and obstruction datasets can be produced that allow for a more accurate small-scale analysis than that which is currently undertaken.

Once produced, the accuracy of ZTV output from this new moderate resolution DSM will be evaluated through comparison with ZTV output from high spatial resolution products (NextMAP, Derived Aerial Photography and LiDAR) in both urban and rural locations. ZTV accuracy from the new product can then be compared with that derived via current industrial practice and other existing mid-resolution data sets, as outlined above. This analysis can then be presented along with proposed uses for this product from ZTV analysis through to contextual 3D mapping. Finally, this study will examine the costs and benefits of the proposed product and its potential to facilitate improved visual impact assessment within commercial environments.

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Biography

David Lock's current role is as the GIS Manager for one of the largest landscape architecture firms in the UK (LDA Design) whilst also undertaking an MSc in GIS from Southampton University. David's role includes working across GIS platforms whilst developing spatial analysis, theoretical visibility and master planning solutions.

Jim Wright is currently a lecturer in Geographical Information Systems, with a particular interest in environmental management and health applications of GIS. Jim also has research interests in water and health in developing countries.