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Automatic Mapping of Physical Urban Problems Using Remotely Sensed Imagery

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ABSTRACT

While big cities are expected to exercise cost-effective, evidence-based planning, many are under reactive management, facing simultaneous problems and limited resources. This project develops a proof-of-concept workflow for the automatic monitoring of physical urban problems by combining remote sensing for detection and cartography for visualization. The example problem treated was the obstructive parking of vehicles on pavements as proxy for restricted urban mobility. Nine aerial images of UK urban areas were processed by a deep learning object detector of standard cars, achieving an F-score of 70.72%. Two large scale map reports of 200m wide areas were produced, featuring car detections and overlaps with topographic mapping features. Complementary analysis included the calculation of total detection window overlap per roadside pavement and its change with time. The proposed method combines uniform city-wide coverage with fast interpretation and can inspire the development of professional urban planning tools.

KEYWORDS

Object Detection, Urban Monitoring

INTRODUCTION

The global trend of rapid urbanisation (Potsiou et al., 2010) entails planning challenges for modern cities. Large disorderly congregations of diverse and interdependent stakeholders create material problems regarding traffic, waste, infrastructure, air quality and health (Chourabi et al., 2012), amplified by outdated traffic-centered planning (European Commission and Directorate General for Mobility and Transport, 2017) and by individualist or traditionalist behaviours (Rode & Hoffman, 2015). Recognitions of the importance of urban space to quality of life have begun to appear at the international policy level (EEA, 2015), including the New Urban Agenda, a UN standard calling for robust science-policy interfaces, sharing mechanisms for globally standardised geographical information and transparent e-governance (United Nations Conference on Housing and Sustainable Urban Development, 2017). Sustainable Development Goal 11 of the UN 2030 Agenda pushes for 'inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries' (Rosa, 2017).

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In line with the above, standardising the monitoring of urban environment quality bears promise in terms of evaluating the current state of infrastructure and planned interventions (Gould, 2011; Leach et al., 2019), but also in creating healthy inter-city competition (Giffinger et al., 2010). Many cities still obtain the state of infrastructure by chance observation of personnel working outdoors. Current monitoring suffers from small coverage, infrequency and unreliability, while legal demands are rising. 'Large amounts of costly technical evidence' are demanded by UK city councils towards local plan making decisions in periods of tight budgetary constraints (Harris, 2017).

The aim of this study was to develop a proof-of-concept for a digital tool that detects well defined manifestations of urban problems in remotely sensed imagery and produces cartographic visualizations to assist urban planners in efficient management, intervention prioritization, and policy.

To this end, an approachable instance of urban problem was found in pedestrian mobility obstructions. Specifically, the inconsiderate parking of vehicles in a way that obstructs pedestrian movement on street-side pavement – fully or partly occupying pedestrian space – was deemed suitable for testing an urban image detector due to the availability of detection software focusing on vehicles, as well as of appropriate geospatial representations of pavements in the UK.

Specific objectives were to:

1. Achieve workable accuracy in detecting cars in remotely sensed imagery.
2. Superimpose detections on topographic geospatial data, perform spatial analysis and output suitable large-scale maps.
3. Integrate the process into one application that conforms to determined user requirements.

The proposed solution involves the massive automatic interpretation of satellite and aerial imagery of urban environments using an appropriate Computer Vision (CV) object detector, with the goal of locating objects related to geographically definable urban problems and superimposing them on geospatial data to extract insight towards more effective urban planning. Existing approaches to gathering urban insight for planners were rejected because they are not scalable (field surveying and local urban sensors), not efficient (manual imagery interpretation, ground observation), not easily manageable and consistent (citizen reporting, big data), or too generic (esri™ geoprocessing tool). Additionally, a preliminary planner survey carried out before the analysis (see below) confirms the professional demand for a relevant tool, and justifies the current focus on automation.

The paper focuses on the demonstration of feasibility and potential in automatic detection, and not the development of a fully documented prototype application. The detection target is also not of primary importance. Parked vehicles serve as an example of freely definable problematic occurrences in the city. Furthermore, the paper only considers infrastructure and environmental issues.

BACKGROUND

In a global 2007 study (Potsiou et al., 2010), seven megacities suffered from largely mutual problems: high density, lack of green areas, loss of cultural heritage; unlawful development and city centre dilapidation; unsustainable land use; congestion and commuting problems; basic resource insecurity; and lacking basic services. In the early 2000s reference was made to pockets of deprivation, exclusion and run-down environments in even the most 'successful' cities (Carpenter, 2006) and an unsustainable quality of life, occasionally even in face of health risks (EEA, 2009).

Urban mobility, vital for keeping cities productive and for maintaining welfare, is threatened by traffic-centred planning (European Commission and Directorate General for Mobility and Transport, 2017) and by individualist or traditionalist behaviours (Rode & Hoffman, 2015). Pedestrians struggle with tight space, obstacles, pollution and risk of accidents in the majority of modern urban environments (Gehl, 2010). At the same time, however, a shift in focus is observed in EU mobility