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Taking the temperature of pedestrian movement in public spaces

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Abstract

Cities require data on pedestrian movement to evaluate the use of public spaces. We propose a system using thermal cameras and Computer Vision (CV) combined with Geographical Information Systems (GIS) to track and assess pedestrian dynamics and behaviors in urban plazas. Thermal cameras operate independent of light and the technique is non-intrusive and preserves privacy. The approach extends the analysis to the GIS domain by capturing georeferenced tracks. We present a pilot study conducted in Copenhagen in 2013. The tracks retrieved by CV are compared to manually annotated ground truth tracks, and an example of pedestrian behavior is analyzed.

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Keywords: tracking; thermal camera; computer vision; GIS; smart cities; pedestrian behaviors; movement pattern analysis; trajectories; visual analysis; space-time cube; urban plazas

1. Introduction

Planners designing well-functioning liveable cities for people need to know how streets and public spaces are being used and how pedestrians move. The classic approach to collect such data is to make sample counts of people at points of interest a few times a year and conduct qualitative urban analysis (Bauer et al. (2009), Gehl and Svarre (2013)). With the rapid development of computing and networking technologies, the miniaturization of sensors, and the introduction of smartphones, a range of new ways to capture data on people's movement have become available in recent years with potential to supplement and extent the classic methods.

Several studies that track people by using data from smartphones and their signals and sensors, such as Bluetooth, Wi-Fi and Global Navigation Satellite System (GNSS), have been made (Delafontaine et al. (2012), Giannotti et al. (2011), Shoval (2008); van Schaick and van der Spek (2008), Zandbergen (2009)). These studies are interesting on a city wide scale to understand macro movement patterns of samples of people, but the spatial accuracy of data from smartphones is not good enough to study detailed pedestrian movement patterns and behaviors in urban streets and plazas. This instead requires accurate and simultaneous tracking of several individuals who may move close together, and where the movement of each individual depends upon interactions with others as well as on the physical layout

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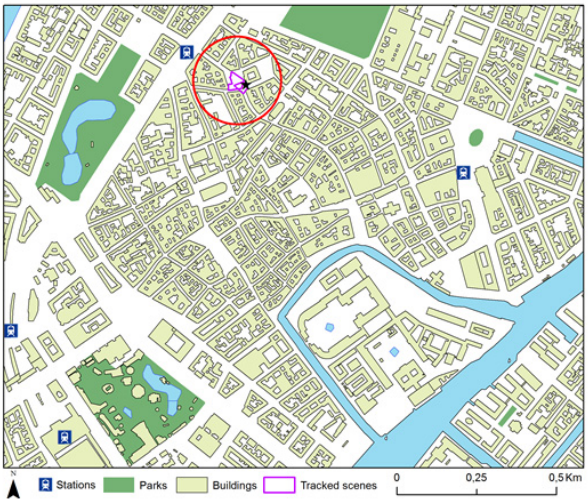

Fig. 1. Overview map of central Copenhagen with the tracked area at 'Kultorvet' highlighted. The background data for this map and the buildings in Fig. 5, 6, and 7 are taken from the open public geographic data courtesy of the Danish Geodata Agency.

of the place and attractors in the space traversed (Moussaïd et al. (2010), Timmermans (2009)). For such micro scale pedestrian studies Computer Vision (CV) based tracking technology is more appropriate to use as it is able to passively register the activity in a plaza without affecting the behavior of people in the space. However there are several challenges to capture reliable data this way. This paper presents results of capturing and exploring data on pedestrian movement with CV tracking technology from a pilot study we conducted in the summer of 2013 in the urban plaza 'Kultorvet' in central Copenhagen (see Fig. 1).

2. Methods

As Computer Vision technology has made rapid progress in recent years (Gowsikhaa et al. (2012), Ko (2011), Moeslund et al. (2011)) we wanted to test it in studies of pedestrian movement patterns and behaviors in everyday traffic in public spaces to assess its potential as a tool to capture such data and aid planners in future Smart Cities (Batty et al. (2012)). Camera surveillance of public spaces in the form of CCTV systems is already installed in many cities, but these systems are often calibrated to aid the police in crime fighting or as traffic cameras to identify vehicles and report on the traffic situation. Police cameras are often Pan-Tilt-Zoom (PTZ) cameras which can be used to zoom in on situations and identify suspects and follow them within a network of cameras around the city, and traffic cameras are focused on vehicle traffic on the road network. To conduct pedestrian movement studies with CV tracking it is necessary to have dedicated cameras with a fixed Field of View (FOV) that can be set up to constantly monitor an Area of Interest (AOI), such as an urban plaza, preferably from an elevated position. This in order to get close to a nadir looking position to avoid the occlusions that occur when people pass each other in front of the camera as CV algorithms can have difficulties to handle occlusions and to distinguish individuals that move close together. The height for optimal camera installation is also a balance between how large a FOV needs to be surveyed versus the level of detail that can be seen in the image. The fact that the further away objects are in a camera's FOV the smaller they appear in the image needs to be taken into account since it is more difficult for CV algorithms to detect and distinguish individuals if they only take up few pixels in the image (Ko (2008)).

Computer Vision algorithms can be applied on video from both normal RGB cameras and thermal cameras. In terms of performance of CV algorithms there are advantages and disadvantages in both technologies that need to be considered (Davis and Sharma (2004), Gade and Moeslund (2014)). Normal RGB cameras record reflected light in three channels, one for the red, green, and blue color respectively, and therefore these cameras depend on sufficient light to operate. RGB sensors are cheap, but they are also somewhat complicated to use for CV tracking of humans in urban scenes. Light conditions change between day and night, and they can change fast in different weather situations