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Work title: Estimating housing vacancy rates at the residential neighborhood level: The case of Zhengzhou, China

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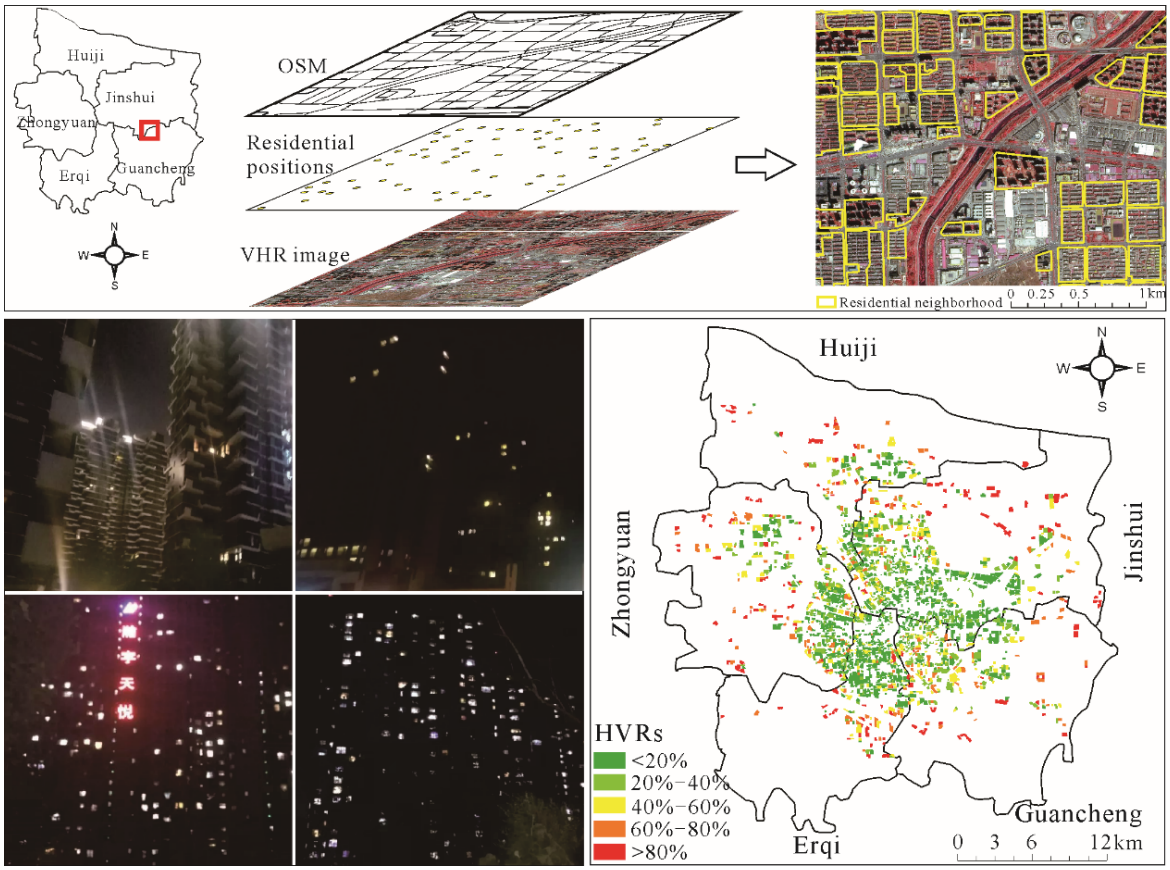
Project Image:



Short project summary (max 250 characters):

Estimating housing vacancy rates (HVR) at the residential neighborhood or even at higher spatial levels is rarely carried out due to the challenges on availability and collection of appropriate data of high spatial resolution. In this study, we introduce a framework for estimating HVR at residential neighborhood level based on selected emerging data sources: night-time light data, very high-resolution image, Open Street Map, housing data and census data. Our developed framework consists of three steps: 1) we extract residential neighborhoods as well as detailed housing information using EO-data; 2) we spatially distribute the census population into residential neighborhoods proportional to night light emissions; 3) we estimate HVR of each residential neighborhood according to the gap between its actual population and the estimated population capacity. Based on this methodology, we find the following main results for our test case of Zhengzhou, China: 1) the average HVR is estimated at 31%; 2) with rising distance to the city center the HVR is increasing.

# Estimating housing vacancy rates at the residential neighborhood level: The case of Zhengzhou, China

## Keywords:

Housing vacancy rate, Residential neighborhood, Remote sensing, Emerging data

## 1. Introduction:

China's strong motivation to build cities led to an oversupply of real estate that far exceeded and still exceeds market demand (Wu et al., 2020). However, neither an official investigation method nor official statistics of China's HVR have been elaborated or announced (Glaeser et al., 2017). The manpower and resources needed by traditional investigation methods are generally too cost-intensive and time-consuming for most unofficial organizations. In this regard, adopting new emerging data sets can be a solution. For instance, Wang et al. (2019) estimated the HVR of metropolitan areas in the USA by using NPP-VIIRS night light data and other geographic data. However, the HVR investigation was generally implemented on spatially coarse units (e.g. urban districts) in the existing studies. The exact HVR of a particular residential neighborhood or even at individual buildings is not available.

For our approach for estimation HVR, we refer to the definition of HVR from the United Nations: the HVR is considered the percentage of unoccupied living space in a residential neighborhood. We introduce and demonstrate a framework using multi emerging data, namely Open Street Map (OSM), Luojia1-01 (LJ1-01) night light data, housing data and very high-resolution (VHR) images from Google earth. Our higher-ranking goal is to estimate the HVR at the residential neighborhood level using those heterogeneous data sets. We apply our methodology to the urban area of Zhengzhou, which is the capital of the Henan Province located in the north-central

parts of China. Ultimately, we analyze the characteristics of the estimated HVRs of all residential neighborhoods in the study area.

## 2. Methods:

We *first* identify residential neighborhoods by a combination of various data sets (see the project image): 1) we segment the study area into multi-scale blocks by using OSM data; 2) we identify residential neighborhoods from all blocks by overlaying their spatial locations with collected housing data; 3) we verify and if necessary, modify the classification results of residential neighborhoods by visual interpretation based on information from the VHR images. *Second*, we linearly distribute the urban population from the census into all classified residential neighborhoods. We estimate their actual population (AP) proportional to their night light DN value collected from LJ1-01 sensor in 2018. *Third*, we estimate the population capacity (PC) of each residential neighborhood by its total living space (TLS) and the per capita living space (PLS) of this area (i.e. PC=TLS/PLS). The PLS of our study area was estimated as 36 $m^2$ in 2018. Finally, we associate the unoccupied living space of residential neighborhoods with the gap between the AP and the PC of residential neighborhoods by referring to the PLS (i.e. 36 $m^2$). Therefore, the estimation formula of HVR in our study is as follows:

$$HVR_i = (1 - AP_i/PC_i) \times 100\%$$

where $HVR_i$ is the housing vacancy rate of a residential neighborhood *i*; $AP_i$ and $PC_i$ are respectively the actual population and the population capacity of a residential neighborhood *i*.

## 3. Results:

We found for all residential neighborhoods in the urban area of Zhengzhou an average HVR of 31% in 2018. This result based on our suggested methodology was higher than the average HVR (21.4%) of urban China estimated by Southwest University of Finance and Economics in 2017 (CHFS, 2018). For assessing the accuracy, we found the estimated HVRs of sample residential neighborhoods (see the project image) to be consistent with their lightning rates at the peak time. All residential neighborhoods in the study area were classified into five categories of HVRs as shown in the project image. Residential neighborhoods with HVRs lower than 20%, i.e. with a comparatively high occupancy rate, were mainly located in the downtown area. On the other hand, residential neighborhoods with HVRs higher than 60%, i.e. with a comparatively low occupancy rate, were mainly found at the urban peripheries. In general, we observed a gradient of rising HVRs from the center to the periphery.

## 4. Conclusions:

In this study, we introduced a framework for estimating HVR based on multiple data sources. By the combination of OSM, LJ1-01 night light, housing data and VHR optical images, the actual urban population and the population capacity of each residential neighborhood were estimated. The gap between the actual urban

population and the estimated population capacity of each residential neighborhood is considered its HVR.

## References: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