Parking Recommendation Service Using Deep Learning

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Abstract, The One of the main reasons for the traffic on the streets is the lack of information about the availability of parking slots on the streets. Therefore, the need for a new service which informs drivers about the available parking is more than before critical. In smart cities, there are various sensors for data collection that can be used to analyze parking management. Remote sensing is one of the most essential options for monitoring the traffic situation in cities due to the possibility of covering large areas and processing data in a short time, and imaging at the desired time. Imaging using unmanned platforms with the very high spatial resolution is available today. In processing big data, deep learning methods based on a convolutional neural networks are very efficient. The purpose of this study is to develop an architecture for a convolutional neural networks based on encoder-decoder networks to determine the available parking lots on the street and to suggest the nearest parking lot according to the driver's location. For a case study, reference data provided by the International Society of Photogrametry and Remote Sensing from Potsdam, Germany. https://doi.org/10.25436/E2PK5S.

Keywords: Parking, Deep Learning, Convolutional Neural Networks, Smart Cities

1 Introduction

Electronic city (or smart city), intending to provide qualitative services at reasonable prices to all, tries to increase productivity and improve the quality of life of people. Meanwhile, transportation as one of the infrastructure systems plays an influential role in providing a platform for creating a smart city [1]. The use of information and communication systems in your transportation can facilitate and pave the way for this. The smart city is a framework created primarily from information and communication technology (ICT) to develop, expand, and promote sustainable development practices of urbanization. IoT-based cloud computing programs receive, analyze, and manage information instantly to help municipalities, companies, and citizens make better decisions to improve their quality of life [2]. People use various ways to connect with the ecosystems of a smart city, such as smartphones, portable intelligent devices, cars, and smart homes [3]. Today, 54% of the world's population lives in different cities, expected to reach 66% by 2050. In total, with population growth, urbanization will add another 2.5 billion to cities over the next three decades [4]. Environmental, social and economic sustainability is one of the most critical points to coordinate with this rapid population expansion and financing of cities. According to the latest research from the institute, Juniper is predicted that the implementation of intelligent traffic management and smart parking plans will save about 4.2 billion people-hours annually by 2021[5]. The Juniper Institute predicts that by 2021, about 2 million smart parking spaces will be created worldwide due to improved private and commercial traffic flows. Finding valuable information in this modern age, technologies that connect vehicles to the Internet and produce large amounts of data have become a key concern [6].

The main goal of this research is implementing a location-based service for indicating the nearest parking slot to drivers by analyzing the data obtained by urban cameras. To analyze camera images, a new convolution neural networks is developed. Using the proposed model, the parked cars, are identified by comparing to the base map, empty parking slots are determined, and when drivers use the app, the nearest parking slot is provided.

2 Case study

The data used in this resesrch are provided by the International Society of Photogrammetry and Remote Sensing for Potsdam. The spatial resolution of data are 5 cm, and the dimensions of each vertical aerial image is 6000 by 6000 pixels. Next to each vertical image, a ground reality map is labeled in several classes, such as buildings, cars, short plants, trees, etc., for which we have used the image containing the car class label. In addition to the presented images, a digital surface model is presented and all outputs are georeferenced. In this research, the initial images are divided into smaller image components to introduce the convolutional neural network. The dimensions of each processed image are considered to be 512 by 512 pixels. In total, 2920 images were created in three bands with dimensions of 512 by 512 where 2420 images are used for network training and 484 images are used to evaluate network performance. To process and implement the convolutional neural network, the GoogleColab system based on Python programming language has been used. The initial processing without using network pre-training with initial data was estimated to take about 3 days. Figure (2) shows the data used in this research.

Fig. 1. the proper three-band color combination

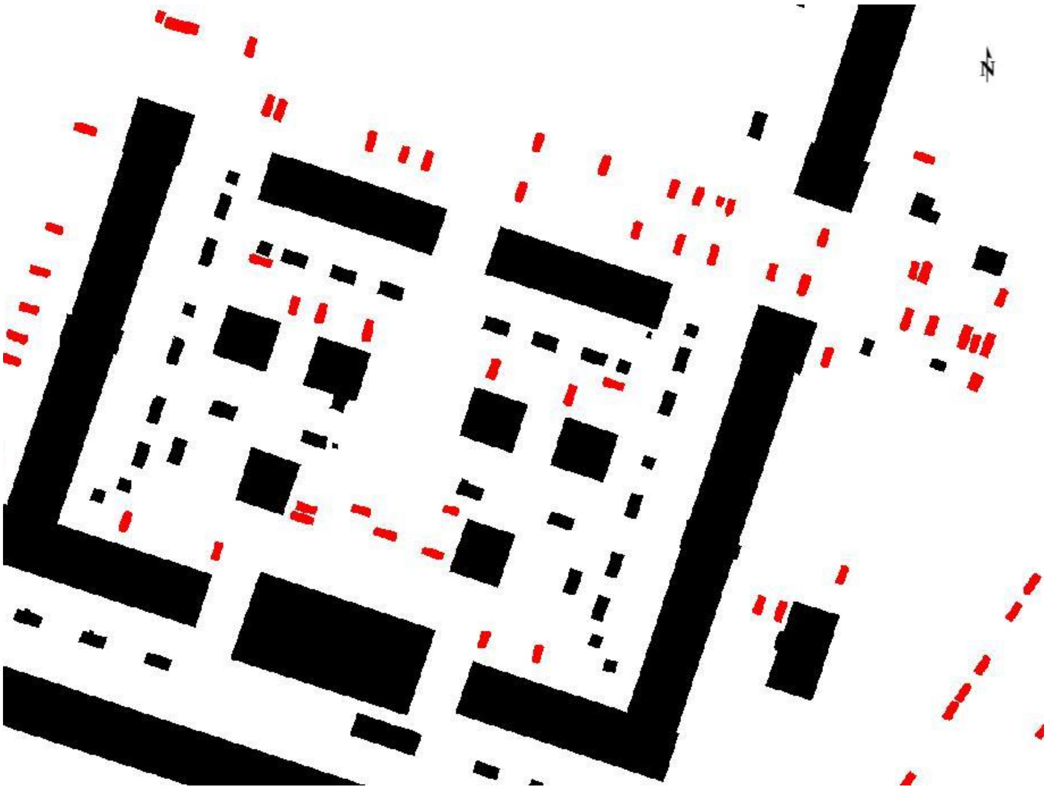

Fig. 2. the ground class map of the car class in red color

Figure (1) shows a part of the study area that is georeferenced, and each band is presented at 256 degrees of brightness. Figure (2) shows the ground class map of the car class in red color.

3 Convolutional Nural Network architecture

The convolutional neural network is designed of encoder-decoder type, which according to the nature of this design, first the dimensions of the image are reduced and its depth is increased. In the second part the reverse process is applied again and finally, the estimation map is made with the dimensions of the input image. The network uses a two-dimensional convolution kernel and the activation function is of the ReLU type and the cost function is of the cross-entropy type. In total, this network has 3,143,842 parameters to estimate. Figure (3) shows the proposed encoder-decoder neural network architecture, which is first performed by reducing the dimensions and increasing the depth in the input image. Then, vice versa in reducing the depth and increasing the dimensions to reach the dimensions equal to the input image.

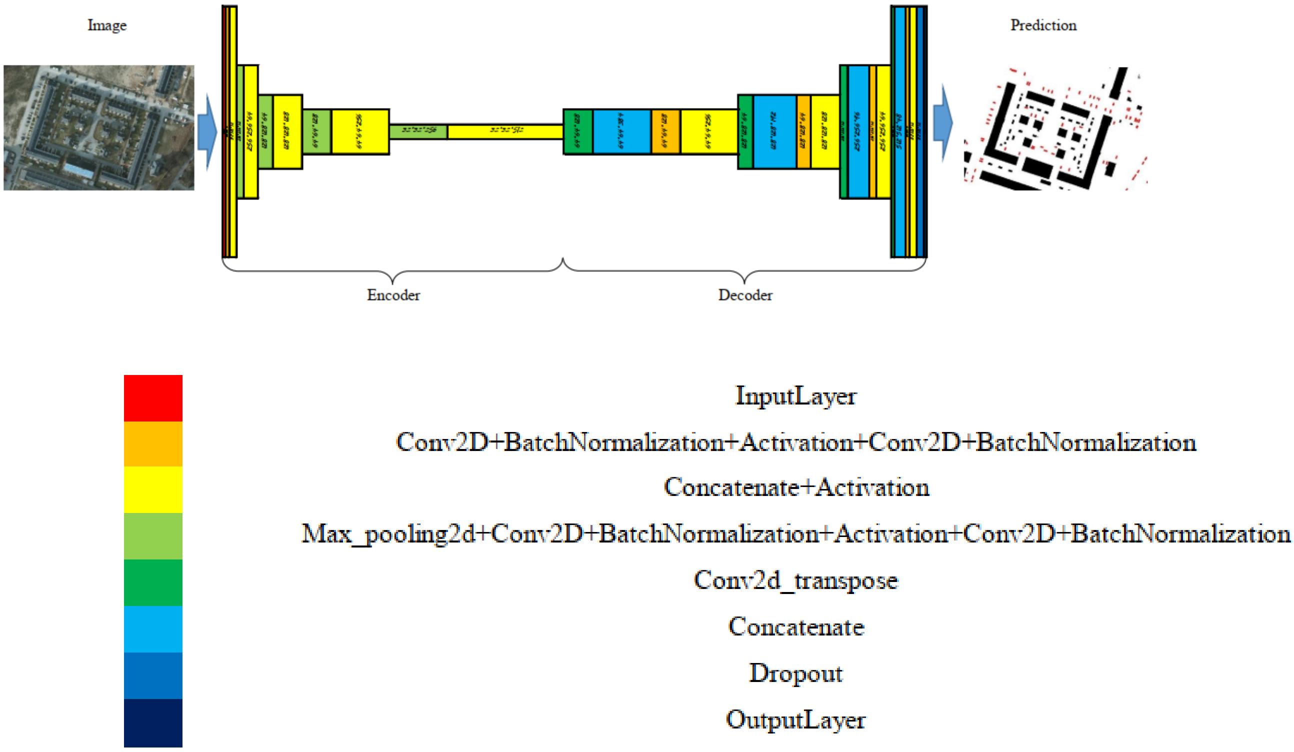

Fig. 3. The proposed encoder-decoder neural network architecture

4 Implementation

In the next step to identify vacant parking lots, a model with piece-wise calculations is presented. In this model, the position of vacant parking slots is calculated by specifying the position of the filled parking slots and matching the output of the neural network with the parking map. The center of the parking slots are considered as a parking indicator and then the nearest parking lot with the shortest route is suggested to the driver based on the position of the car (Fig. 4-6).

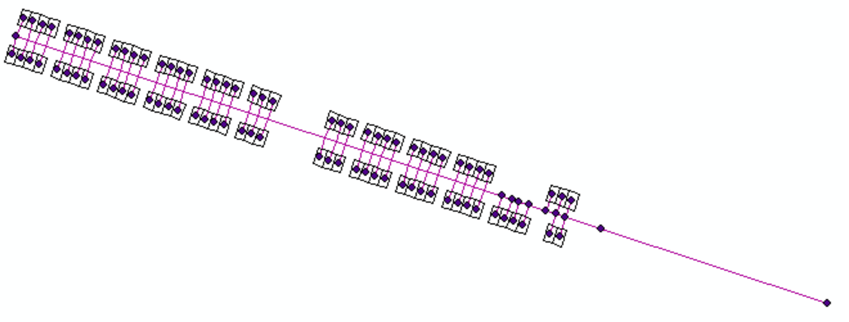

Fig. 4. Converting raster to vector

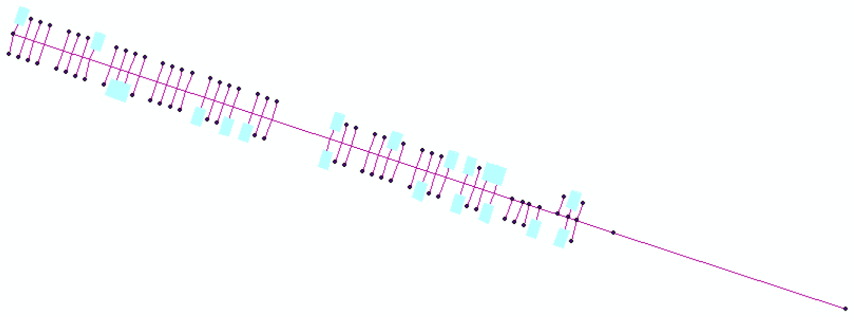

Fig. 5. Mapping filled parkings

Fig. 6. The best vacant parking near the car's position

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