VILNIUS UNIVERSITY
FACULTY OF MATHEMATICS AND INFORMATICS
INSTITUTE OF COMPUTER SCIENCE
DEPARTMENT OF COMPUTATIONAL AND DATA MODELING

Information Technologies 2 year

Algorithm Analysis of Object detection in Satellite Images

Objektų aptikimo palydoviniuose vaizduose algoritmų analizė

Done by:
Daria Tovsohan signature

Supervisor:
assoc. prof. Linas Bukauskas

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Contents

Abstract

Santrauka

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This is a summary in Lithuanian Shorter than introduction, but longer than abstract.

Introduction

Object detection in imagery data is the process of identifying objects within the image. Object detection is commonly used in urban planning, environmental monitoring, disaster response, healthcare and agriculture. In this field machine learning and deep learning techniques are mainly used to achieve desired results. As there are nearly 7300 active satellites orbiting the Earth, the need to proceed with the imagery data acquired from them grows more and more.

Thus, satellite images are a challenging task for deep learning methods as they have more pixels rather than classical photography, the geo-referenced images should be considered from which the coordinates into flat Earth projection will be extracted, you may also face sun angle, atmosphere conditions and satellite positions, objects are represented only by a few pixels and there is not enough information about it to use classical computer vision. That is why deep learning comes into the game with the help of which huge images can be processed all at once and later divided into smaller tiles.

In this coursework, we will look at deep learning methods used in processing satellite imagery, the logic behind them and direct implementation.

The following tasks will be completed in order to accomplish this goal:

1. Perform a thorough analysis of the literature on object detection in images, taking into account various techniques, data sets, and assessment criteria.

2. Select a data set that satisfies the criteria (in our case the data set of images made by satellites).

3. Perform data processing.

4. Analyze and put into practice a deep learning method, train it on the custom data set and use it to predict objects on unseen data.

5. Evaluating their advantages and disadvantages of deep learning method.

6. Highlight the main issues and areas for further study in this field, such as the requirement for higher data quality, more effective algorithms, and more reliable detection techniques.

To sum up, this coursework's objective is to provide a thorough examination of deep learning elements that influence the effectiveness of object detection in satellite images and to pinpoint areas that still require research and development in this fascinating and quickly developing sphere.

1 Related Work

1.1 Outline of current object detection methods in satellite images

Object detection in satellite images is an active study field with the variety of methods that have been put forth for it. Down below is the overview of the most commonly used techniques nowadays:

1. **Traditional image processing method:** In order to capture desired objects in satellite images, these methods use filters and other image processing techniques. Examples:

- Edge detection - this method finds edges of objects by identifying changes in intensity of color.
- Thresholding - this method divides the image into background and foreground depending on threshold value.
- Template matching - this method makes a comparison between the small template image and larger satellite image to find similarities.

2. **Feature-based method:** These methods use texture, color, shape features to capture objects in satellite images. Examples:
    - SIFT (Scale-invariant feature transform) - detecting keypoints and extracting features that are invariant to scale changes.
    - SURF (Speeded up robust features) - a faster version of SIFT that is also invariant to scale changes.
    - HOG (Histogram of oriented gradients) - representing the image as a histogram of local gradients.
3. **Deep learning method:** These methods automatically read data from satellite images via CNNs (convolutional neural networks). Examples:
    - SSD (Single-shot detector) - a method that makes a prediction of object bounding boxes in a single iteration, based on CNN.
    - YOLO (You Only Look Once) - one more method similar to SSD, which is as well based on CNN.
    - Faster R-CNN - method based on CNN, the main difference between it and SSD/YOLO is that it uses a region proposal network to generate object proposals.
4. **Transfer learning method:** These methods are based on using already pre-trained learning models. Examples:
    - Fine-tuning - fine-tunes the pre-trained CNN and applies it on small datasets of satellite images.
    - Feature extraction - as well as fine-tuning uses a pre-trained CNN and trains a separate classifier on top of these features for object detection in images.
5. **Supervised learning algorithms:** Examples:
    - K-nearest neighbors algorithm - a non-parametric, supervised learning classifier, which uses proximity to make classifications or predictions about the grouping of an individual data point.
    - Logistic regression - used for predicting the categorical dependent variable using a given set of independent variables.
    - Convolutional Neural Network (CNN) - a deep learning algorithm that can take in an input image, assign importance to various aspects/objects in the image, and be able to differentiate one from the other.
    - Support vector machine (SVM) - a supervised algorithm that performs classification or regression tasks by constructing a divider that separates data in two categories.

1.2 Overview of deep learning

Deep learning is the machine learning technique that teaches computers how lo learn by example. The "deep" part refers to the amount of hidden layers in the neural network. Deep learning models are trained on large sets of labeled data.

1.3 Evaluation of the benefits and drawbacks of studied method

Drawbacks:

1. Deep learning needs large amounts of data.
2. Deep learning models learn via observation, in other words they know only what was in the data they were trained on.
3. Deep learning models require high-performing graphics processing units, random access memory and a hard disk drive or RAM-based solid-state drive.

2 Methodology

2.1 A description of the analysis's data set

2.2 Detailed explanation of how the method was implemented

2.3 Measures for assessing the effectiveness of the algorithm

3 Results

3.1 Presentation of the evaluation results

3.2 A comparison of the algorithm's performance with other cutting-edge methods

3.3 A discussion of the findings and their relevance

Conclusions and Recommendations

Future Work

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