Detection and Registration of Blurred Locations in Online Satellite Images

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Introduction

Some regions are synthetically blurred in online satellite map services since they may contain military bases, natural gas pipes, nuclear facilities etc. In this work, our goal is to design a software which can automatically detect those regions. In these context, we propose three different methods in order to detect blurred regions in online satellite map services. Among these methods, CNN-based and the Laplacian-based approaches provide very promising results. Laplacian filtering method is very easy to implement. However, experimental results show that the CNN-based method outperforms the other approaches in terms of accuracy. Depending on application environment and requirements, one may choose one of these methods. We found the blurred locations on online satellite map services (Google, Yandex, Bing Maps) in [1] and using these locations we extracted 126 images. Work is being done on these images.

Methods

CNN Technique: In this study, we use a six layer Convolutional Neural Networks to filter out the locally blurred input image. After filtering, we split the resulting image into grids. Each grid element is called a patch. In order to decide if the patch is blurred or not, we calculate the variance of each patch and compare it to an adaptive threshold. If it is less than the threshold, we say that the patch is blurred. The adaptive threshold is calculated by computing the variance of the overall image. Then, it is divided by an experimentally determined scaler.

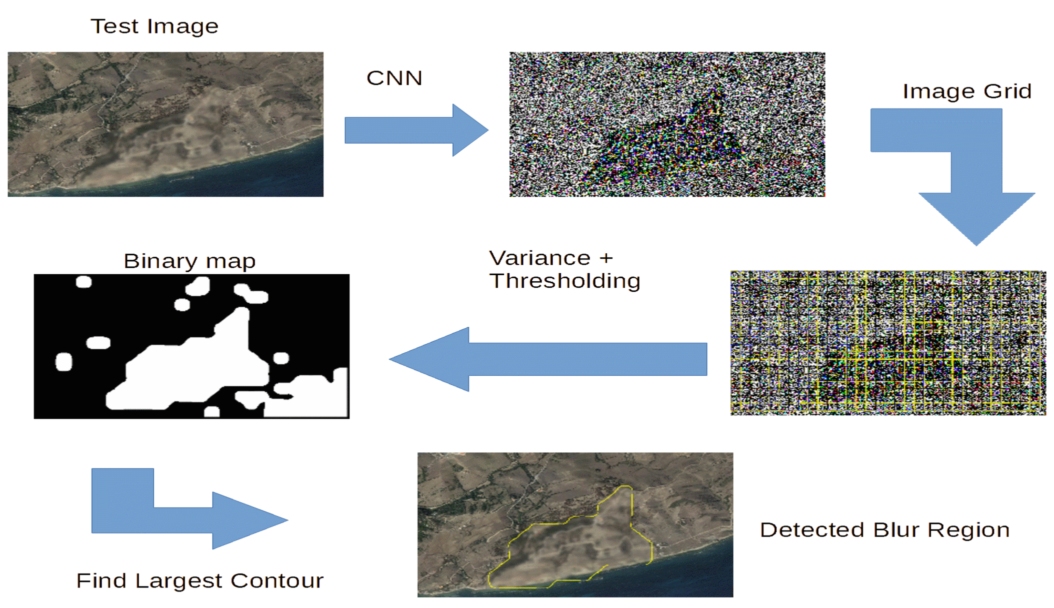


Figure 1: CNN Technique block diagram.

Laplacian Filtering: As a second method, we use a Laplacian kernel to filter out the locally blurred input image. The kernel is a 3x3 matrix whose entries are [(0,-1,0), (-1,4,-1), (0,-1,0)]. After filtering, similar to the previous method, we split the resulting image into grids. The variance of each grid element is compared to the threshold that we defined using the aforementioned technique. If it is less than the threshold, we say that the grid element is blurred.

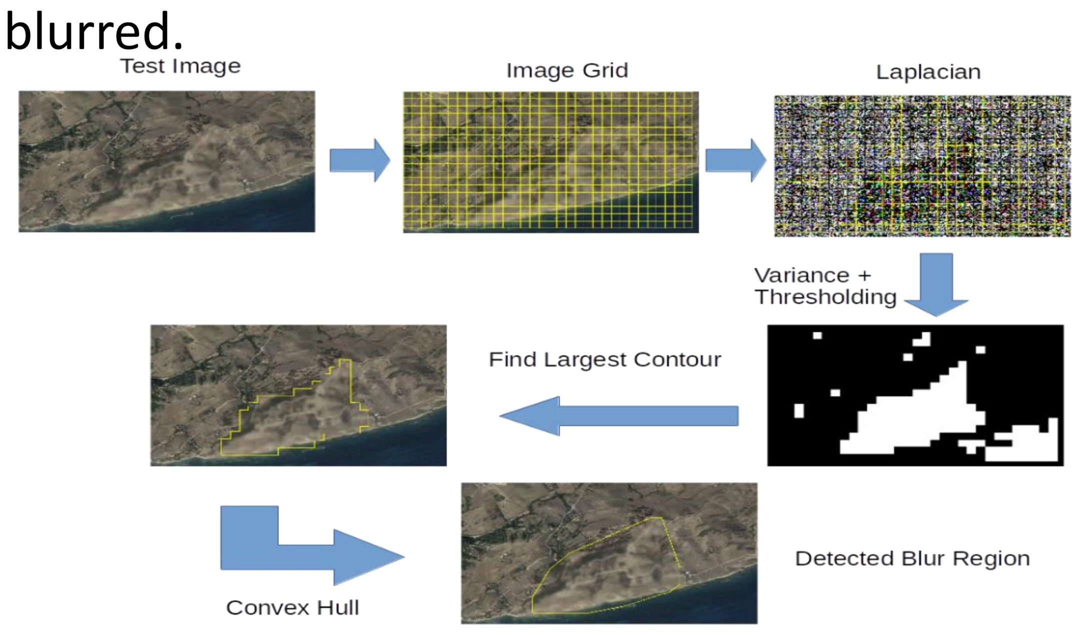


Figure 2: Laplace Operator Technique block diagram.

High Pass Filter: In the third approach, we used a standard high pass filter kernel, [(-1,-1,-1), (-1, 8, -1), (-1,-1,-1)]/9, considering that the previously used Laplacian kernel is a sort of high pass filter. We observed that this technique is also able to detect locally blurred regions using the steps previously explained. However, we noticed that the performance of this method is worse than the previous methods.

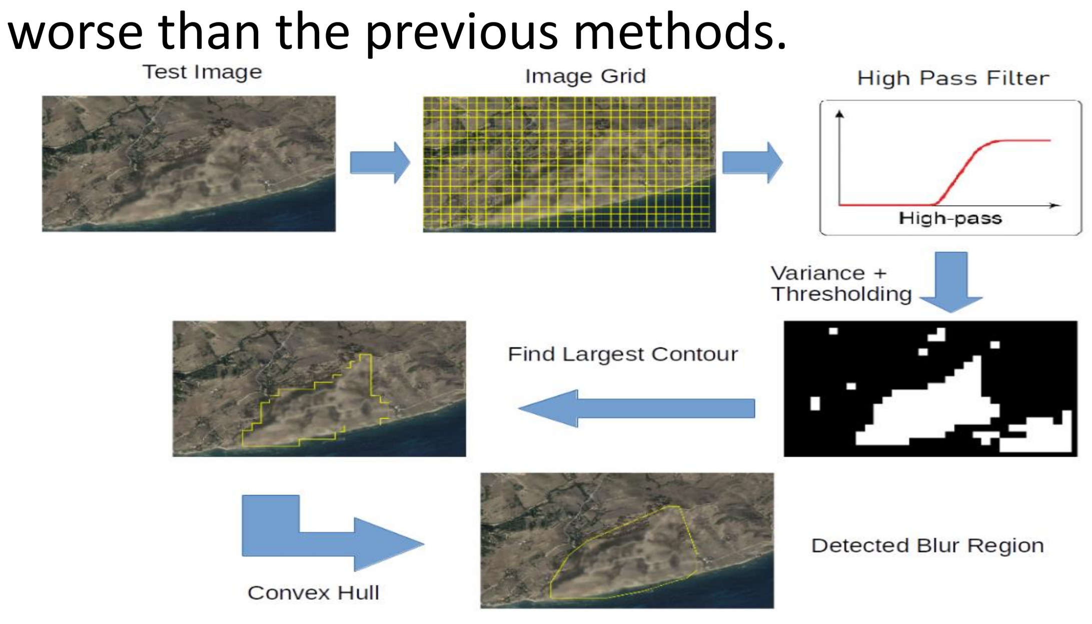
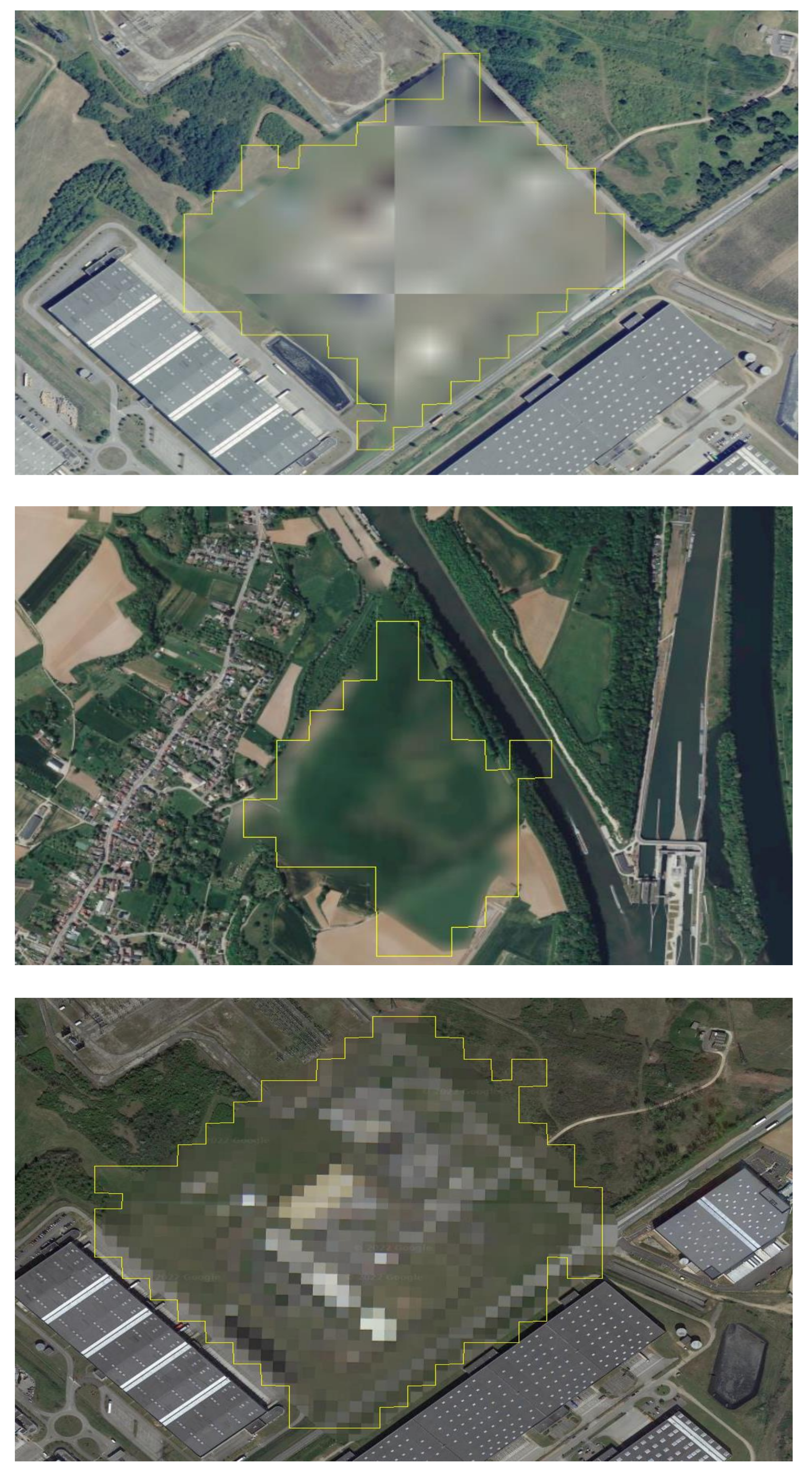


Figure 3: High Pass Filter Technique block diagram.

Application

Convolutional Neural Network



Laplacian Filtering

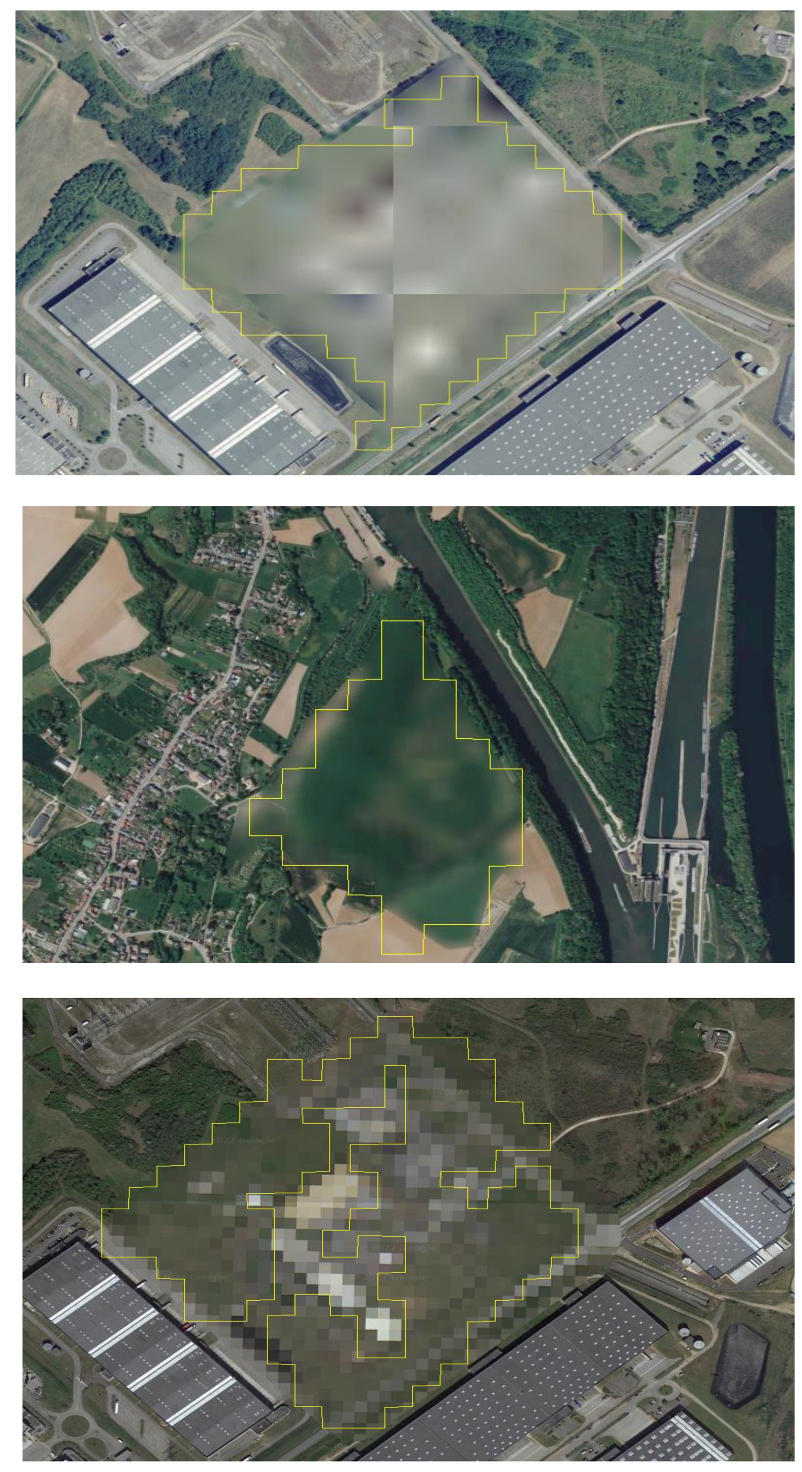


Figure 4: Detected blurred regions using CNN. **Figure 5:** Detected blurred regions using Laplacian Filter.

Results

We use similar evaluation method as proposed in [2].

True Negative (TN)	Image is not blurred and predicted as not blurred.
False Positive (FP)	Image is not blurred but predicted as blurred.
False Negative (FN)	Image is blurred but predicted as not blurred.
True Positive (TP)	Image is blurred and predicted as blurred.

Table 1: Confusion matrix model.

Accuracy	Measure to which the result of an experiment matches the correct value and it's calculated by the ratio which is given below. $A = \frac{TP+TN}{FP+FN+TP+TN}$
Execution Time (s)	Total number of run-time during the execution of images.
Avg Time (s)	Average of run-time during the execution of images.

Table 2 : Accuracy and execution time.

Precision Score	A measure of relevance between the retrieved result and the observation. $P = \frac{TP}{FP+TP}$
Recall Score	Measure of the ability to retrieve the relevant results. $R = \frac{TP}{FN+TP}$
F-measure Score	Measure of a test's accuracy and is defined as the weighted harmonic mean (average) of the precision and recall of the test. $F = 2 \times \frac{P \times R}{P+R}$

Table 3 : Evaluation measures.

Blur Detection	TN	FP	FN	TP	Accuracy	Avg Time (msec)
CNN	25	3	7	91	0.92	129.64
Laplacian Filtering	26	5	9	86	0.89	56.14
High Pass Filter	24	14	7	81	0.83	80.01

Table 4 : Confusion matrix results.

Blur Detection	Precision Score	Recall Score	F-measure Score	Avg Time (msec)
CNN	0.97	0.93	0.95	129.64
Laplacian Filtering	0.95	0.91	0.93	56.14
High Pass Filter	0.85	0.92	0.88	80.01

Table 5 : Comparison of blur detection techniques.

References

[1] ***Wikipedia. List of satellite map images with missing or unclear data. https://en.wikipedia.org/wiki/List_of_satellite_map_images_with_missing_or_unclear_data. 2019.***

[2] **Roxanne A Pagaduan, Ma Christina R Aragon, and Ruji P Medina. "iblurdetect:Image blur detection techniques assessment and evaluation study". In: Proceedings of the International Conference on Culture Heritage, Education, Sustainable Tourism, and Innovation Technologies-CESIT. 2021, pp. 286–291.**

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