VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belgaum -590014, Karnataka.

PROJECT PHASE 1 REPORT
On

Removal of occluding fences from an image

Submitted by

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Under the Guidance of
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Associate Professor, BMSCE

In partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING
In
COMPUTER SCIENCE AND ENGINEERING

B. M. S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
BENGALURU-560019

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B. M. S. College of Engineering,
Bull Temple Road, Bengaluru, 560019
(Affiliated To Visvesvaraya Technological University, Belgaum)
Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the project work entitled "**Removal of occluding fences from an image**" carried out by Ms. Deepthi Bhat (1BM16CS003), Ms. Aditi Awasthi (1BM16CS008) and Ms. Medhini Oak (1BM16CS047) who are bonafide students of **B. M. S. College of Engineering, Bengaluru 560019.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2019. The project report has been approved as it satisfies the academic requirements with respect to **Project Phase 1 (16CS7DCPP1)** work prescribed for the said degree.

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1.______________________________ ________________________

2. ______________________________ ________________________

TABLE OF CONTENTS

ABSTRACT

Photographers are often hindered in their attempts at capturing pictures by unsuitable imaging conditions. One such condition is the presence of grills, fences or enclosures between the camera and the scene of interest. Due to growing security concerns for the safety of both private property and public places, the presence of such barriers cannot be avoided. Hence, there is a need for a tool which can remove the occlusion from the clicked image as if it were never there and replace it with content that blends with the background. In this project, we intend to detect and remove the occlusion from a given input image and then generate the content to be filled in the area occupied by the occlusion by using an image-processing algorithm. This system employs a defencing algorithm, followed by an exemplar-based image in-painting algorithm. The resulting image will be rid of the fence and will resemble an image taken without the presence of occlusions.

DECLARATION

We, hereby declare that the Project Phase-1 work entitled "**Removal of occluding fences from an image**" is a bonafide work and has been carried out by us under the guidance of Dr. Kayarvizhy N, Associate Professor, Department of Computer Science and Engineering, B.M.S. College of Engineering, Bengaluru, in partial fulfillment of the requirements of the degree of Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University, Belgaum.

We further declare that, to the best of our knowledge and belief, this project has not been submitted either in part or in full to any other university for the award of any degree.

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This to certify that these candidates are students of Computer Science and Engineering Department of B.M.S. College of Engineering and have carried out the project work titled "**Removal of occluding fences from an image**" as Project Phase-1 work. It is in partial fulfillment for completing the requirement for the award of B.E. degree by VTU. The works is original and duly certify the same.

Project Guide **Signature and Date**

Dr. Kayarvizhy N

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LIST OF TABLES

LIST OF FIGURES

Chapter 1
INTRODUCTION

Image processing is an area of study which deals with the manipulation of digital images through a computer in order to obtain an enhanced image or to extract some information of significance from it. It comes under the domain of signal processing. The input signal is essentially an image and the output yielded may be another image or certain noteworthy attributes associated with it.
In the present day, image processing is among the most rapidly growing technologies. It is a primary research area in the field of computer science and engineering.

Mathematically, an image can be viewed as a two dimensional signal. It can be represented by the function f(x, y). The value of f(x, y) at any point gives the value of the pixel at that point of an image. This allows us the means to handle images in a more skilful way and transform them according to the requirement, instead of looking at them as just a collection of pixels which make sense only to the human eye and not to the computer.

1.1 OVERVIEW

Due to the inclusion of image capturing devices into portable devices like smart phones and digital cameras, the number of pictures generated has increased in recent times. Amateur photographers capture numerous pictures when they find an opportune moment, but they are often hampered by unwanted obstructions like fences, grills, enclosures or reflective surfaces. These structures distract the viewers from the actual focus of the picture, thereby ruining its visual appeal. Even if there are editing mechanisms available for photographers to remove obstructions from the picture, the removal of fence-like structures from the picture is particularly tedious as they generally cover the entire picture and it is difficult to remove them without losing some parts of the original picture. Instead of undergoing the harrowing process of manually editing such occlusions, a solution can be offered using image processing algorithms, where the fence is automatically detected and filled without or with minimal manual assistance.

1.2 MOTIVATION

Fences are one of the primary means of protection against intruders. They are used almost everywhere, from the protection of private property to public places like zoos, national heritage sites, scenic meadows and so on. While they are used as a layer of security, they also have drawbacks when it comes to photography since fences and enclosures cannot be removed from the frame by changing the angle of the camera or the plane of focus. While safety and security are the primary concerns, the presence of these obstructions ruins the aesthetic experience of the picture. This problem can be tackled by using image processing to remove the fence from the photograph after it has been clicked. By using accurate de-fencing and image inpainting techniques, the occlusions can be effectively removed and filled with content that fits the original image in a natural way, thereby removing the need to compromise with distorted photographs or performing manual editing on them.

1.3 OBJECTIVE

The focus of our project is to remove fence-like occlusions from the input image to generate a complete image without distortions. By using the frequency spectrum of the image, the fence in the image is segregated from the background. Support Vector Machine classification is applied to the resultant de-fenced image to improve the quality of the segregation. The resultant de-fenced image will contain a mask of empty space that was previously occupied by the fence. It is then given as input to an exemplar-based image in-painting algorithm which uses the pixel inhomogeneity factor as a computing measure for the filling mechanism. This results in an occlusion-free image, in which the areas occupied by the fence are filled by the in-painting algorithm by using other parts of the image as a reference.

1.4 SCOPE

The algorithm will take the input as an image which requires occlusion removal. The image will undergo de-fencing and produce an image that will contain the area to be in-painted as a mask, which is the input to the in-painting algorithm. The resulting image will be an occlusion-free image.

1.5 EXISTING SYSTEMS

Defencing:

1. Video De-fencing tool
2. Texture Detection in Images to identify Fence-like Structures
3. Detection and Restoration of Image from Multi-Color Fence Occlusions

Inpainting:

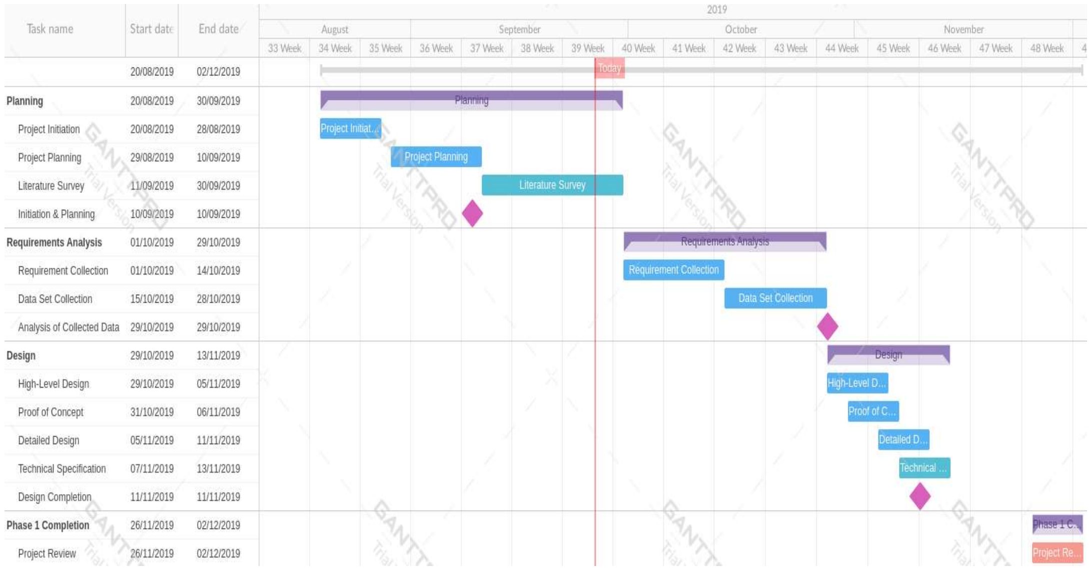
1. Exemplar based image inpainting
2. Deep Convolutional Generative Adversarial Net (DCGAN) based inpainting

1.6 PROPOSED SYSTEM

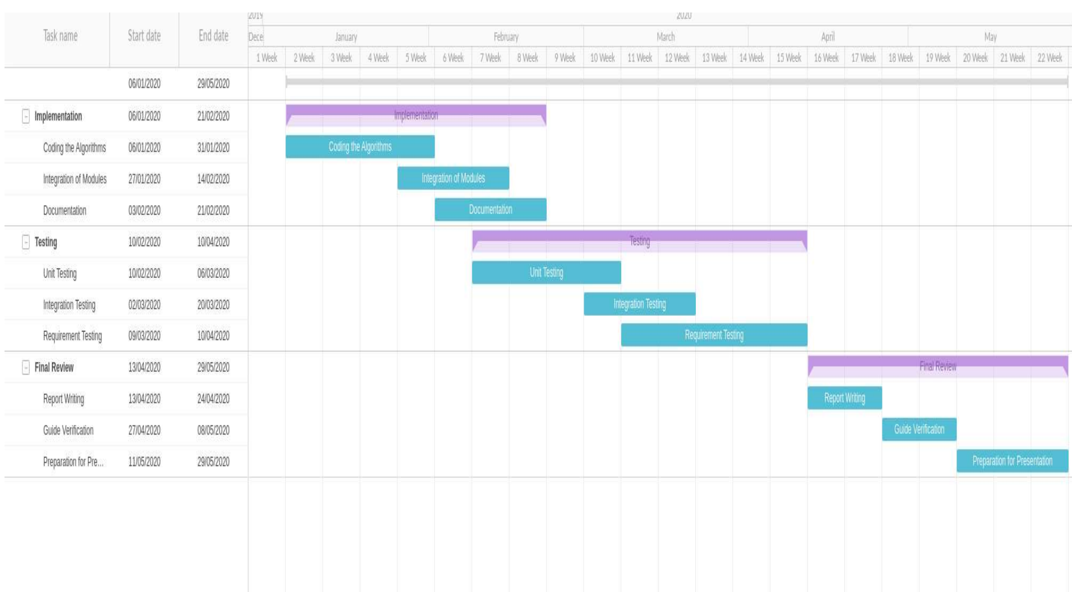
The system essentially performs its task in 2 phases: first, it detects the fence and uses image processing techniques as well as an SVM classifier to produce an intermediate result without the fence masked and highlighted. In the next phase, this mask is filled with pixels to form a coherent image by extrapolating from the known ones (inpainting) by making use of an improved version of the foundational Criminisi algorithm.

1.7 WORK PLAN

Phase- I



Phase- II



Chapter 2
LITERATURE SURVEY

1. Exemplar based image inpainting (Criminisi's Method):

The method proposed in [1] was one of the first methods to suggest the use of example patch information to fill missing patches in an image. It separates the image into target region; the region being filled in, and source region; the region with known pixel information. The target region is divided into patches of size 9 by 9 pixels. But the user should change this to a size slightly bigger than the biggest texture element or a Texel. The algorithm consists of two parts: deciding the filling order of the patches and filling the patches with appropriate colour and texture. To decide the filling order of the patches, a priority term is assigned to each patch. This priority is given by a "confidence term" and by a "data term". The patch P with the highest priority is selected to be filled in. To fill this selected patch with highest priority, a patch from the source region Q is selected that is lost similar to the given patch. This is done by calculating sum of squared distances between Q and the known pixels in P. After selecting appropriate Q, the pixel information from Q is copied onto P. The confidence terms of the patches are updated and this process is repeated until all the patches are filled. The proposed method outperformed every other existing method at that time and was able to remove large objects from images. Many improvements on the original algorithm have been proposed since such as using an image segmentation algorithm to segment the image based on topography before applying the algorithm used in [2], using a patch shifting scheme for cases where Criminisi's method might fail as used in [3], understanding the depth information to guide appropriate scale transformation as used in [4], using pixel inhomogeneity factor to drive the priority function as used in [5] and many more.

2. Deep Convolutional Generative Adversarial Net (DCGAN) based inpainting:

Content aware inpainting algorithms use the neighbouring pixel information to fill in target pixels. However, in some cases there is a need for the algorithm to have some intuitive knowledge as to what to fill as described in [6]. Supervised learning is used to solve that problem. DCGAN is essentially a convolutional neural network that is used to generate new content. It understands the semantics of the entire image and suggests new relevant content to complete the image. DCGANs consist of two parts, the discriminator and the generator. The discriminator comprises four convolution two dimensional layers activated by Rectified Linear Unit and lastly a fully connected layer. The generator comprises of a linear layer along with a reshape transformation so that the input is in appropriate dimensions followed by four convolution two dimensional transpose layers activated by Rectified Linear Units. The generator creates new content to fill into the target region whereas the discriminator distinguishes between what is real and fake. It is observed that using DCGAN produces superior inpainting although it takes longer time to run. However, it does not apply to every scenario since its applicability is limited by the training dataset. [7] uses Convolutional neural networks to inpaint parts of the human body that is obstructed by occlusions.

3. Video De-fencing:

The technique described in [8] involves automatic detection and removal of occlusions from video clips. This method takes advantage of the fact that consecutive frames aligned frame by frame has information of the pixels in the de-fenced video. Therefore, the fence-free video can be obtained by substituting the fence pixels to the pixel information in the frames with an unobstructed view. The algorithm can be divided into two parts: estimation of the term “Probability of Fence” (PoF) and pixel selection. The goal of PoF estimation is to find the confidence term of every fence pixel of every frame. This is done by calculating visual parallax by analyzing and inferring the visual flow and image appearance. After finding the affected pixels, pixel restoration is performed. This is done with an improved image alignment algorithm. This algorithm computes the optical flow by making use of a “robust temporal median filter” (R-TMF) which is able to give the correct pixel information even when the fence pixels dominate the pixel collection. This part of the algorithm determines its complexity since it is the most time consuming. The method proposed gave promising results on a dataset of actual world consumer videos with static scenes. However this method was unable to properly restore the video when the depth of the fence was the same as the background or with moving objects in the background. Methods described in [9], [10], [11] try to improve on this algorithm.

4. Texture Detection to identify fences:

The method described in [12] aims to automatically detect fences or fence-like objects present in the foreground of an image. An application of this is removal of occluding cages or wire mesh in pictures of animals in enclosures. The process is achieved in three stages: Frequency domain filtering, Multi-resolution Processing and SVM Classification. In frequency domain filtering, the image is considered as a two dimensional discrete time signal. The quasi periodic signal here is the fence which can be filtered using a bandpass filter in the frequency domain. For Multiresolution Processing, wavelet transformation is used. It uses a coarser to finer strategy where the fence masks at different levels of wavelet pyramid are combined. The detected fence mask, after multi-resolution processing, classifies a large number of pixels not picked up on the fence texture. Hence, some samples from the fence mask were picked and the features of those sample pixels were used to train an SVM classifier so that the fence texture can be segmented. The fence detection is complete after this stage. Exemplar based image inpainting technique is then used to fill the fence region in this approach. The proposed method works well for fence texture with different shapes, sizes, colours and orientations. Fence texture detection was successful not only for images having fence in the foreground but also for images having fence in the background.

5. A deep learning approach for video de-fencing:

The aim of the proposed method described in [13] is to formulate a sparsity based optimization framework to fill-in fence pixels in a video by using a convolutional neural network. The neural network consists of five layers, two convolutional and two pooling layers and finally a fully connected output layer. The output maps from the fourth layer are concatenated to form a vector while training and this is given to the next layer as input. The final output layer contains two neurons which correspond to each class. These are fully connected with the previous layer by weights. A linear sigmoid function is used to modulate the responses of the output layer. This output produces a resultant score for each class. Like in traditional video defencing, it is assumed that the areas of the frame that are covered by one frame might be revealed in the subsequent frames. This motion is estimated using the optical flow and wrapping matrix. Split Bregman Iterative framework is used to obtain the best estimate of the de-fenced image. The proposed algorithm is able to inpaint video-based frames with superior accuracy when compared to traditional video inpainting technique.

6. Detection and Restoration of Image from Multi-Color Fence Occlusions:

The method described in [28] aims to detect fences having different orientation, shapes, color and texture. The image is first converted from RGB to YCbCr. Histograms are computed for each channel of g(x, y) image. These histograms are analyzed to select threshold values based on which the segmentation of the fence is done. The segmented mask is amended by using morphological operations like elimination of false positives and insertion of false negatives. The fence mask obtained after an amendment is used for masking the original image. A hybrid inpainting algorithm is used to restore the occluded area. This algorithm is able to detect the fence in the image which may be of different orientation, texture, shape, multicolor and occluded. It is reliable with an average true positive rate of more than 95% and true negative rate of more than 97% of all the figures presented.

Chapter 3
REQUIREMENT ANALYSIS AND SPECIFICATION

3.1 FUNCTIONAL REQUIREMENTS

Given a picture with occluding elements, the system should effectively remove and inpaint the occlusions to produce a picture without distortions. (There should be enough coherence in the actual background to extrapolate and produce a complete image without occlusions. This depends on the discretion of the user.)

3.2 NON-FUNCTIONAL REQUIREMENTS

We aim at attaining the following attributes of quality in our project:

1. **Usability:** We want the project to be accessible to amateur photographers who do not have experience with complex editing tools. Hence the system needs to be user-friendly and easily comprehensible.

2. **Reliability:** Consistency in the system performance is very necessary and it should give accurate results for every input that falls within the scope of the project.

3. **Performance:** The system should perform as expected in an environment that meets the recommended specifications.

4. **Scalability:** The system design should be such that it can be extended to process batches of input images without reduction in performance

5. **Maintainability:** The code should be understandable and modularized so that making further improvements is not cumbersome.

3.3 HARDWARE REQUIREMENTS

Processor	Intel i5 / AMD A6 or greater
Graphics Card	NVIDIA GTX / AMD Radeon RX or greater
Memory (RAM)	Minimum 16GB
GPU	4GB Nvidia
System specification	x64-based processor, 64-bit Operating System

Table 3.3: Hardware Requirements

3.4 SOFTWARE REQUIREMENTS

Programming Language used:

- Python

Libraries Required:

- OpenCV
- Matplotlib
- Numpy

Chapter 4
DESIGN

4.1 HIGH-LEVEL DESIGN

4.1.1 SYSTEM ARCHITECTURE

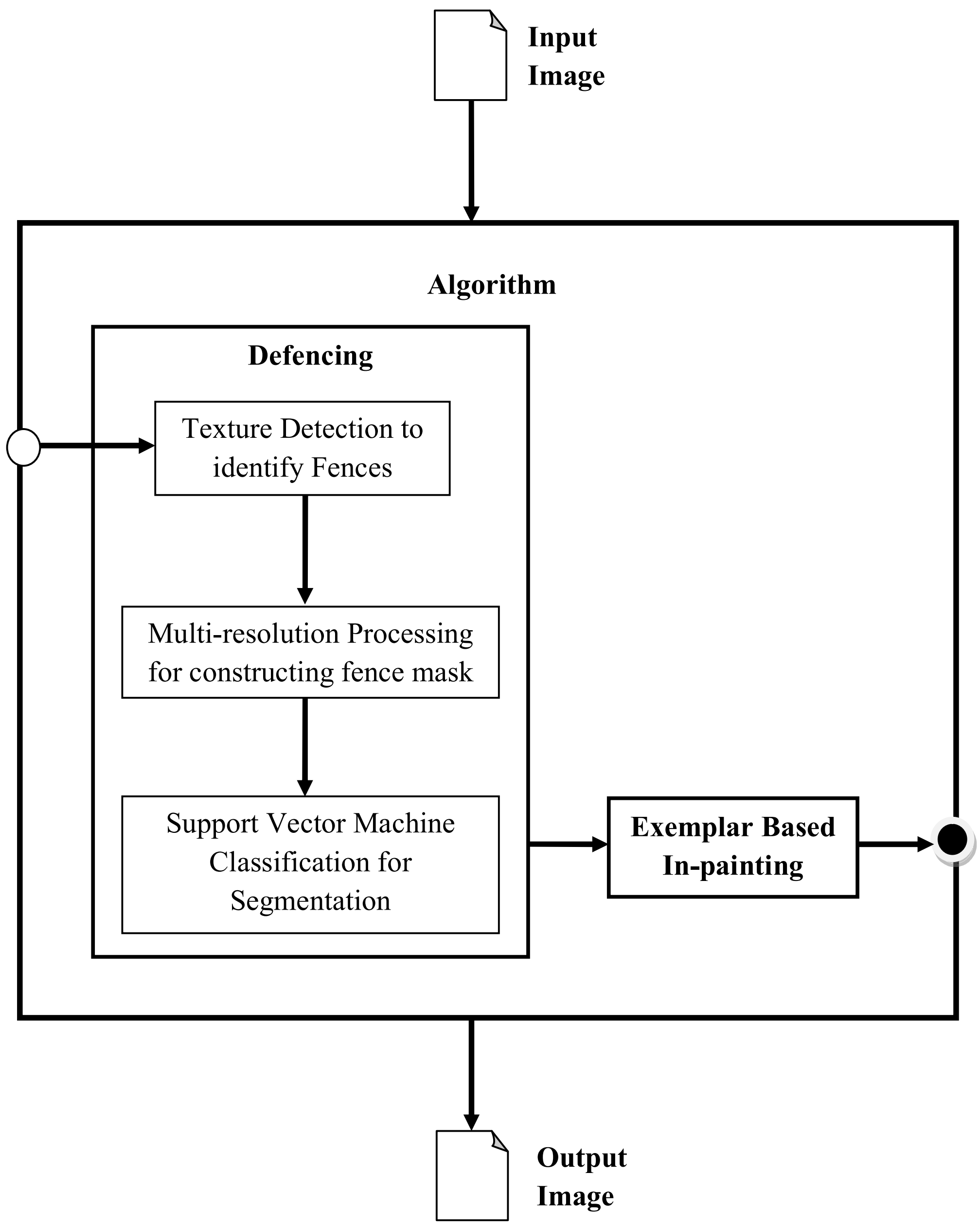


Figure 4.1.1: System Architecture

4.1.2 ABSTRACT SPECIFICATION OF SUB-SYSTEM

a) **De-fencer:**

   i. Filtering in the Frequency domain:
      Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform
      Peak frequency filter and band pass filter

   ii. Multi-resolution processing
      Wavelet decomposition (H, V, D)
      Thresholding function

   iii. SVM classification

b) **In-painter:**

   i. Pixel in-homogeneity Factor (PIF) computation

   ii. Confidence term calculation

   iii. Priority computation

   iv. Exemplar portion decider

4.2 METHODOLOGY

A digital image can be represented as a two - dimensional function f(x, y), where ‘x’ and ‘y’ are Cartesian coordinates and the magnitude of the function at any point denotes the intensity of the image at that point.

a) In the proposed framework, the input is first transformed into the frequency domain (using Fourier Transform). Each point will then represent a particular frequency present in the original form of the image (in spatial domain). The representation of an image in the frequency domain makes it easier to access and pinpoint its geometric attributes.

   Applying peak frequency filter: The edges in an image appear as high-frequency components in the Fourier domain. Filters are used to extract only certain features of the image that we are interested in by using the principle of superimposition. They are mask arrays of the same size as the original image. We can apply a High-Frequency Pass Filter to this transformed image and it will block all low frequencies and only allow high frequencies to go through.

   Applying band pass frequency filter: Dominant frequencies of quasi-periodic structures like fences are usually present in the middle frequency range, so a band pass filter is used to extract these frequencies. The image is then converted back to the spatial domain using inverse transform

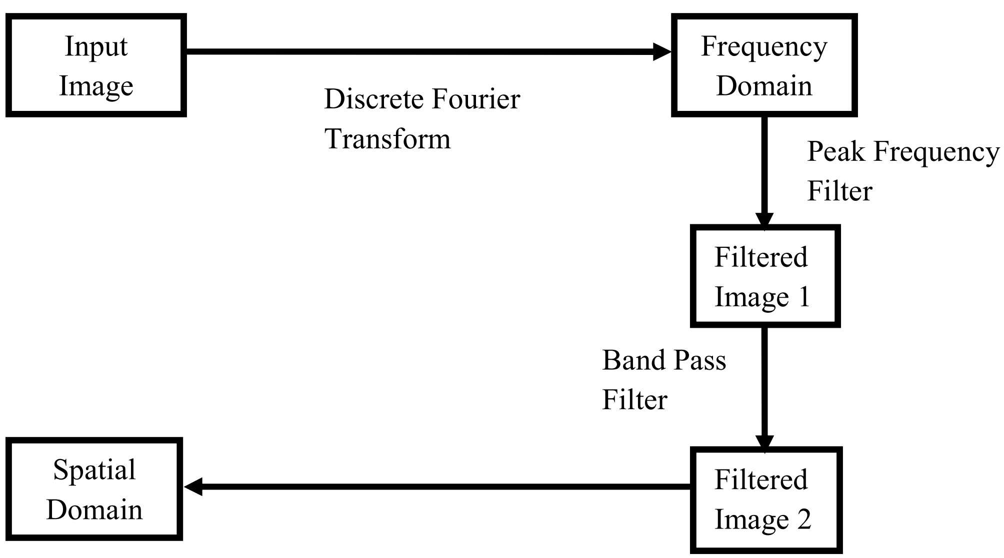


Figure 4.2.1: Quasi-periodic texture filtering

b) Wavelet decomposition provides a complete image representation since decomposition is performed according to both scale and orientation the way it is done psychophysically. The wavelets obtained measure intensity variations in different directions. A system of cascading filter banks (low-pass and high-pass filters satisfying certain specific constraints) can be used to implement this.
Thresholding is performed to extract the fence masks at 3 different resolution levels. Final fence mask is constructed by performing an OR operation of the (V, H, D) fence masks at each level. Then the masks at different levels are combined to reduce attenuation and find out the exact pixel location of the fence

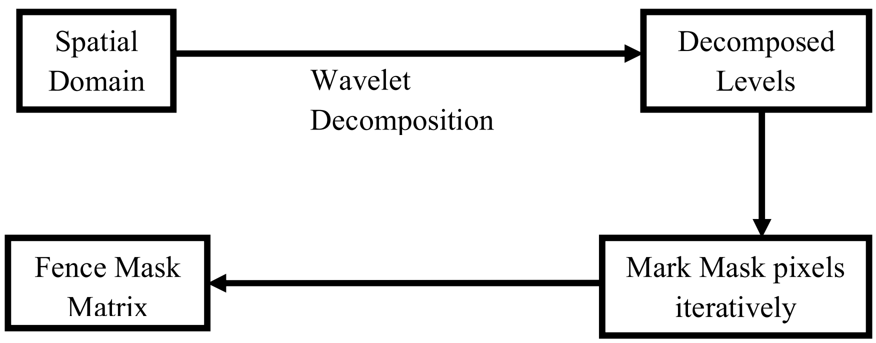


Figure 4.2.2: Multi-resolution processing for fence mask formation

c) Features of sample pixels from the fence mask thus obtained are used to train a Support Vector Machine classifier in order to further segment the fence texture. 2 different masks are used for this purpose – a thin one (represents fence) and a thick one (negation of which represents background). RGB colour channels and gradient direction are used as feature set for classification.

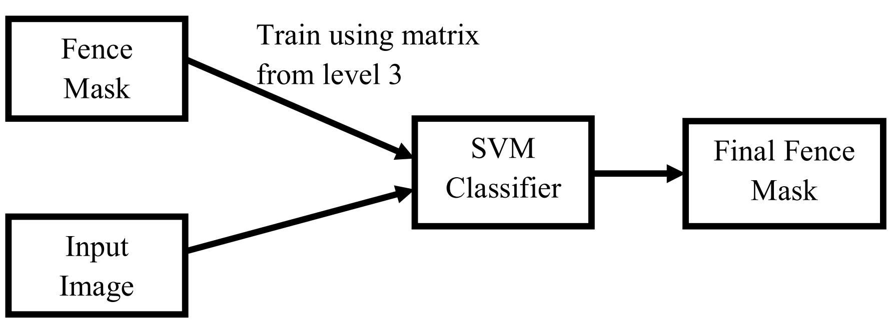


Figure 4.2.3: Support Vector Machine Classification for Segmentation

d) Once the fence mask is demarcated, its boundary is extracted. The confidence term is initialized and pixel in-homogeneity factor is calculated.
The filling area is identified, patch priorities are computed and the maximum priority patch is chosen as the patch to be filled in the current iteration. The exemplar portion to fill it is selected based on the minimum sum of squared differences and inpainting is done. Then, the confidence term and PIF are updated for all the patches. This cycle continues till the image is complete and the fence mask has been entirely covered.

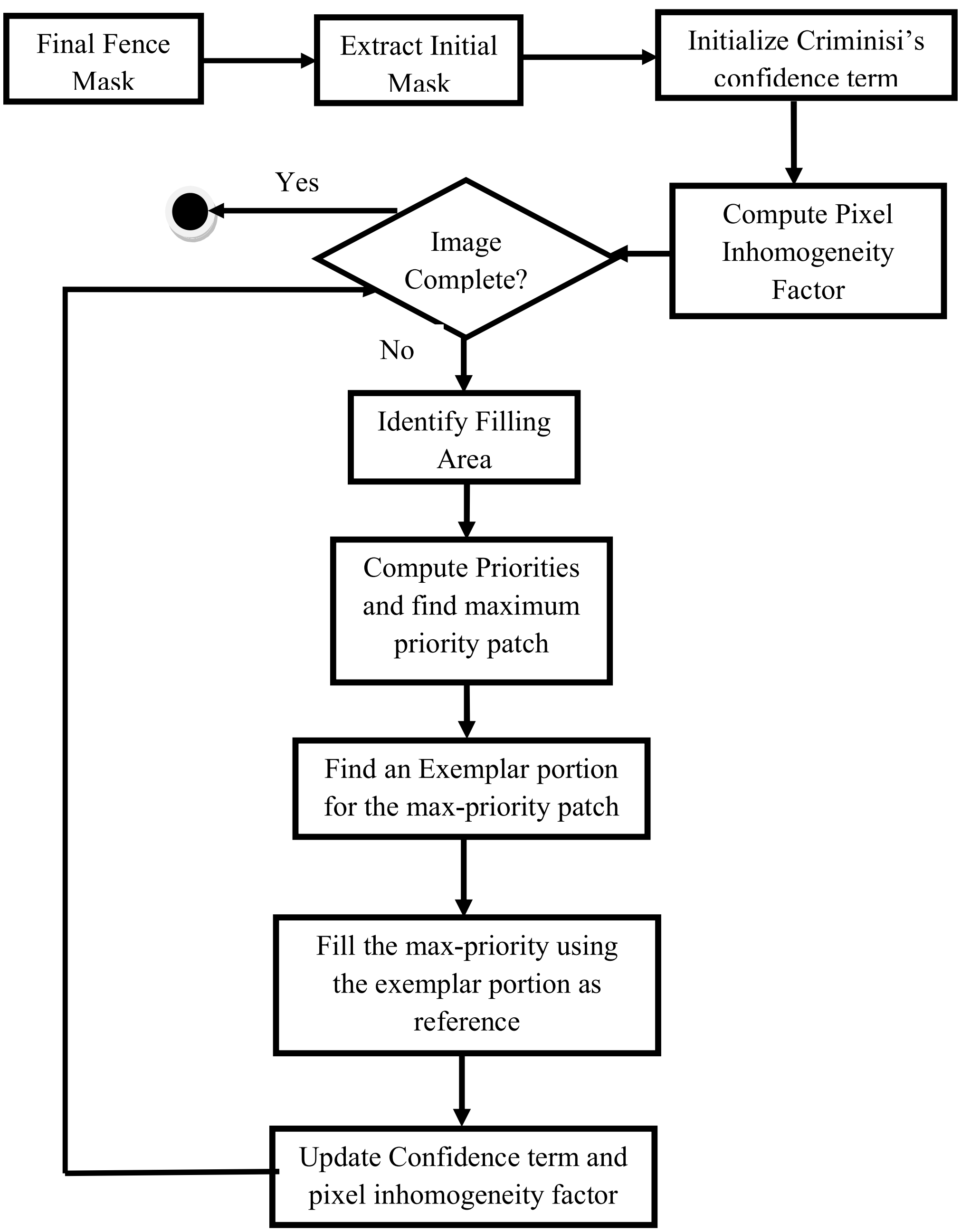


Figure 4.2.4: Exemplar Based Inpainting

Chapter 5
CONCLUSION AND FUTURE ENHANCEMENTS

5.1 CONCLUSION

In this project, we have demonstrated how to remove occluding elements from images using advanced image processing techniques which involve complex mathematics. It is remarkable to see the impact of pure math-based computer applications in such varied real world problems. This project tackles a task which is quite cumbersome for photographers when done manually. We hope this tool is incorporated into the mainstream set of tools that are used professionally and that image processing experts contribute to make it even more effective.

5.2 FUTURE WORK

Currently, the algorithm can be applied only to Quasi-Periodic structures (repetitive geometric patterns) in images. This work can be extended to include random structures and reflective occlusion (distortions created due to reflective surfaces present in the frame). It can also be enhanced to perform de-fencing and in-painting for videos.

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APPENDIX 1
Attainment of POs and PSOs

B.M.S. College of Engineering
Department of Computer Science and Engineering

Batch no. : Date:

Project Title: **Removal of occluding fences from an image**

Programme Outcomes	**Level (1/2/3)**	**Justification (if addressed)**
PO1	2	Applying the knowledge of mathematics and image processing to develop the project to address the current challenges in the domain of image completion.
PO2	2	Analyzing the problem statement, performing research in the project domain and quoting the same in the literature survey.
PO3	2	Designing the solution for the problem statement with ethical and social considerations in mind.
PO4	2	Referring many publications of similar research base and analysis of their results.
PO5	3	Utilizing the latest tools and libraries of image processing to come up with accurate and improved solutions.
PO6	3	Developing solutions in adherence to ethical and moral standards defined in the professional engineering practice.
PO7	2	Producing sustainable results which cause no harm to the user or the environment.
PO8	3	Adhering to the ethics and norms of the engineering practice.
PO9	3	Distributing work among the team members in an equal and efficient manner and conducting periodic review for knowledge sharing
PO10	3	Communicating our research to the society via well-written reports, self-explanatory presentations and thorough documentation
PO11	3	Quoting cost and resource requirements at the beginning of the project and following the same throughout the duration of the project
PO12	3	Recognizing scope for future enhancements to the project and documenting the same for future generations
PSO1	2	Using standard software development practices at every step of the development process
PSO2	3	Producing a user-friendly system that can be used with minimum domain knowledge
PSO3	2	Optimizing codes to the best of our abilities and increasing the efficiency of the design throughout the development process.

APPENDIX 2

Plagiarism report

Removal of occluding fences from an image

ORIGINALITY REPORT

10%	7%	4%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.uav.ro Internet Source	3%
2	Jonna, Sankaraganesh, Krishna K. Nakka, and Rajiv R. Sahay. "My camera can see through fences: A deep learning approach for image de-fencing", 2015 3rd IAPR Asian Conference on Pattern Recognition (ACPR), 2015. Publication	1%
3	baadalsg.inflibnet.ac.in Internet Source	1%
4	Submitted to Christ University Student Paper	1%
5	Yadong Mu, Wei Liu, Shuicheng Yan. "Video De-Fencing", IEEE Transactions on Circuits and Systems for Video Technology, 2014 Publication	<1%
6	arxiv.org Internet Source	<1%
7	iosrjournals.org	

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8	Submitted to City University of Hong Kong Student Paper	<1%
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10	ijarece.org Internet Source	<1%
11	hdl.handle.net Internet Source	<1%
12	Muhammad Shahid Farid, Arif Mahmood, Marco Grangetto. "Image de-fencing framework with hybrid inpainting algorithm", Signal, Image and Video Processing, 2016 Publication	<1%
13	Muhammad Shahid Farid, Maurizio Lucenteforte, Marco Grangetto. "DOST: a distributed object segmentation tool", Multimedia Tools and Applications, 2017 Publication	<1%
14	Naoki Matsumura, Hiroki Tokura, Yuki Kuroda, Yasuaki Ito, Koji Nakano. "Tile Art Image Generation Using Conditional Generative Adversarial Networks", 2018 Sixth International Symposium on Computing and Networking	<1%

	Workshops (CANDARW), 2018 Publication	
15	Submitted to University of Southampton Student Paper	<1%
16	Submitted to Higher Education Commission Pakistan Student Paper	<1%
17	cs231n.stanford.edu Internet Source	<1%
18	"Foundations of Intelligent Systems", Springer Science and Business Media LLC, 2014 Publication	<1%
19	"Computer Vision – ECCV 2016 Workshops", Springer Science and Business Media LLC, 2016 Publication	<1%
20	Chen Du, Byeongkeun Kang, Zheng Xu, Ji Dai, Truong Nguyen. "Accurate and Efficient Video De-Fencing Using Convolutional Neural Networks and Temporal Information", 2018 IEEE International Conference on Multimedia and Expo (ICME), 2018 Publication	<1%

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