Report 2100301

Engineering Practice

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Company Name	**Infosys Limited**
	Corporate Headquarters Plot No. 44 & 97A,Electronics City, Hosur Road, Bangalore, India- 560 100
Supervisor	**Mr. Harikrishna G.N. Rai**
Duration	**March 18, 2013 - May 31, 2013**
Total Hours	**481 hours**

Placement Service Centre

Student Affairs

Faculty of Engineering

Chulalongkorn University

Prologue

As part of Computer Engineering program in Chulalongkorn University, students are required to undergo internship on the 3rd years. Receiving the opportunity to intern at Infosys Limited (Instep Program), I've got a chance to research on Digital Image Processing, mainly focus on blue detection algorithms.

The report contains 5 section including, 1) Introduction, 2) Company Detail, 3) Project Detail, 4) Conclusion, 5) Appendix, giving the information about the whole internship.

My duration of internship was March 18, 2013 to May 31, 2013, 481 hours. Working under the supervision of Harikrishna G.N. Rai, I received the experience and skill sets as a researcher, and learnt how to work with team.

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1 Introduction

1.1) Internship Objectives

• Internships will provide basic knowledge for engineering job.• Internships will provide principles of teamwork.

• Internships will provide the understanding of risk management in engineering job.

• Internships will provide principles of engineering management.

• Internships will provide the understanding of role of engineer in society.

• Internships will provide procedures to adapt the knowledge into the real world problems

1.2) Duration and Working Environment

The internship duration was from March 18, 2013 to May 31,2013. During the internship, the facilities were provided to maintain working condition (for e.g. pc, internet connection, stationary, bicycle, phone, etc.). My team had a discussion at least once a week, and the mentor closely worked with me to keep on progress and provide guidance

1.3) Project Mentor

Harikrishna G.N. Rai is Research Analyst at INFOSYS Technologies Ltd, leading Image and Video Analytics research group at Infosys Labs which is research arm of Infosys. His major focus is on driving R&D programs in the area of Computer Vision, Image & Video Processing for providing industry specific imaging solutions to varied industry sectors like Healthcare, Automotive, Retail, Multimedia etc.

His research interests include - Digital Image Processing, Medical Imaging, Computer Vision, Image & Video Analytics, Pattern Recognition, Machine learning. He filed several patent including,

- method and system for performing clinical data mining
- a system and method for modeling a region segmented image
- system and method for measuring camber on a surface
- methods for detecting and recognizing a moving object in video and devices thereof
- methods and systems for enabling vision based inventory management

He has intensive work experience in imaging domain and prior to Infosys he worked at,

- Research Analyst: **Infosys, Bangalore**
- Software Architect: **Cerner Corporation**
- Member of Technical Staff - Lead: **SHARP**
- Systems Executive: **Manmar Technologies Ltd**

2 Company Detail

Infosys Limited

2.1) Address

Corporate Headquarters Plot No. 44 & 97A,Electronics City, Hosur Road, Bangalore, India- 560 100

2.2) History

Established in 1981, Infosys is a NYSE listed global consulting and IT services company with more than 155,000 employees. From a capital of US$ 250, we have grown to become a US$ 7.398 billion (FY14 revenues) company with a market capitalization of approximately US$ 31 billion.

In our journey of over 30 years, we have catalyzed some of the major changes that have led to India's emergence as the global destination for software services talent. We pioneered the Global Delivery Model and became the first IT company from India to be listed on NASDAQ. Our employee stock options program created some of India's first salaried millionaires.

2.3) Scope

Infosys is a global leader in business consulting and technology solutions. As a proven partner focused on building tomorrow’s enterprise, Infosys enables clients in more than 30 countries to outperform the competition and stay ahead of the innovation curve. We create value for our clients by helping them surmount current challenges and see into the future of their business.

Our experience gives our clients a distinct advantage. In addition to transforming their business, we can efficiently manage their operations as well. Our ability to execute on our ideas and deploy the most efficient delivery models are at the foundation of our three decades of success. A standout example is our Global Agile Delivery - a powerful blend of distributed delivery and Agile software development methods – for efficient IT development. We deliver business value in global scalability, process efficiency and cost optimization for our clients.

Our expertise spans industries. From helping build lighter and stronger passenger jets and creating more fuel efficient smart cars, to enabling banks to provide financial inclusion to the most remote corners of the globe, Infosys delivers powerful innovations. And in doing so, we change the way the world works and lives.

Ranked in the top tier of Forbes’ 100 most innovative companies, Infosys provides enterprises with strategic insights on what lies ahead. Our focus on 7 core mega-trends provides a framework to uncover opportunities for innovation-led growth. It guides us as we help organizations realize the promise and potential of the emerging digital consumer, smarter organizations, and pervasive computing.

We help enterprises transform and thrive in a changing world through strategic consulting and the co-creation of breakthrough solutions. Infosys delivers business results by linking enterprise strategy to execution, resulting in powerful outcomes that help clients realize new efficiencies and revenue opportunities. Our integrated services are strategically bundled to deliver more value to clients and support the needs of enterprises to embrace the power of mobility, sustainability, big data and cloud computing.

Since its foundation, Infosys has focused on bringing to life great ideas for enterprise solutions. And yet, it's more than just innovation that has won us the confidence of our stakeholders. At Infosys, we adhere to the highest ethical standards in our relationship with our clients, our employees, and our shareholders. We believe our responsibilities also extend beyond the boundaries of business. That's why we established the Infosys Foundation to provide assistance to some of the most socially and economically depressed sectors of the communities in which we work.

An entrepreneurial adventure that began with seven engineers and $250, Infosys is now a publicly traded company driven by 150,000+ relentless innovators and annual revenues of more than $7B.

At Infosys, we are unafraid to challenge the status quo. Delivering innovative business solutions that make our clients more competitive. Reinventing business models to exploit emerging opportunities in the industries we serve. And providing answers to real-world problems that improve the lives of the world's people.

3 Project Detail

3.1) Background

Digital Image Processing has become an important research area and found in many industries. Intelligent systems which are highly dependent on images have been built to match the requirements. The common problems arising in this are the complex structural nature of images, and the huge data size. One of the decisive goals is to find an effective blur detection algorithm for camera-captured document images.

Processing of mobile camera captured document image has gained significant interest recently due to an increase in the use of mobile devices. As a result, several related work in literature on document image quality that were initially developed for scanned document images have been extended to camera-captured images. Methods focusing only on the perceptual quality of images for blur detection and correction are not directly applicable for camera-captured images. In most cases, camera-captured document image is intended to be used in automated processing. Therefore, machine readability takes precedence over human readability. Achieving machine readability through OCR tools for text in these document images is important as well as extremely challenging to achieve.

3.2) Working plan

Week 1 & 2	**Week 3 & 4**
- Survey of research papers on Motion Blur and Defocus detection - Hands on with OpenCV 2.3 - Data capture using mobile device for selected bills - Simulating blur in images (test dataset)	- Implementation of local gradient based approach OR based on survey - Implementation of eigen image based approach - Testing 2 methods using test data
Week 5 & 6	**Week 7 & 8**
- Analysis of results for identifying failure cases - Improving the existing implementation - Experimentation and benchmarking	- Integration of algorithm with real system - Testing end-to-end system with real data
Week 9 & 10	**Week 11**
- Survey and implementation of text detector	- Report/research paper preparation - Final presentation preparations

3.3) Research Detail

Confidential data has been removed due to Infosys Limited policy.

3.3.1) Blur Image

Blur image is an image that cannot be seen clearly, or less distinct. We focus on 2 type of blur including,

1. **Out of focus blur**

If the angle of light entry of certain pixel doesn't match the focal length, it will be shifted from the real value by PSF (point spread function).

We focus on 2 type of PSF, because these 2 are uniform, easy to induce and nearly cover all type of out of focus blur.

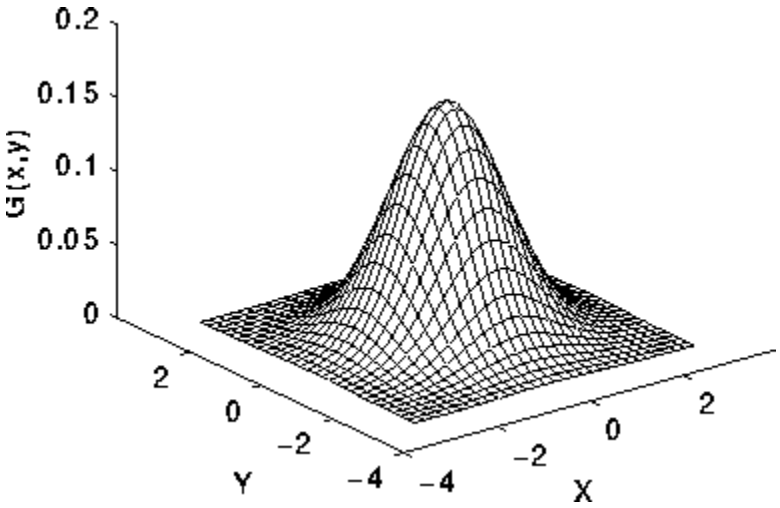
• Average blur

By averaging certain patch size and replace the center pixel, results in smoothing the image.

• Gaussian blur

By applying Gaussian equation for each pixel or the image, results in smoothing the image.

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$



Example of Kernel

$$\frac{1}{273}\begin{bmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 26 & 16 & 4 \\ 7 & 26 & 41 & 26 & 7 \\ 4 & 16 & 26 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{bmatrix}$$

2. Motion blur

If the camera is shaken at the capture moment, the pixel will be average by the direction and velocity. (suppose we have the image with these pixel values.

1	255	15	255	10

We move the camera at certain velocity on the right direction which gives 5 pixel of motion blur transformation. If we look at the first pixel, it'll change to (1+255+15+255+10)/5 = 107

Kernel

0.2	0.2	0.2	0.2	0.2

3.3.2) Blur Detection Algorithm

3.3.2.1: Shadow correction

Shadow of the user who took the image and illumination usually becomes error factors in blur detection algorithm. So the first step is to remove the shadow and normalize the image before we apply blur detection.

3.3.2.2: Gradient

An image gradient is a directional change in the intensity or color in an image. Since the intensity function of a digital image is only known at discrete points, derivatives of this function cannot be defined unless we assume that there is an underlying continuous intensity function which has been sampled at the image points. With some additional assumptions, the derivative of the continuous intensity function can be computed as a function on the sampled intensity function, i.e., the digital image. It turns out that the derivatives at any particular point are functions of the intensity values at virtually all image points. However, approximations of these derivative functions can be defined at lesser or larger degrees of accuracy.

The gradient of an image is given by the formula :

$$\nabla f = \frac{\partial f}{\partial x}\hat{x} + \frac{\partial f}{\partial y}\hat{y},$$

The gradient direction can be calculated by the formula :

$$\theta = \operatorname{atan2}\left(\frac{\partial f}{\partial y}, \frac{\partial f}{\partial x}\right).$$

3.3.2.3: Laplacian

Laplacian is a differential operator given by the divergence of the gradient of a function on Euclidean space. The Laplacian $\Delta f(p)$ of a function f at a point p, up to a constant depending on the dimension, is the rate at which the average value of f over spheres centered at p, deviates from f(p) as the radius of the sphere grows. In a Cartesian coordinate system, the Laplacian is given by sum of second partial derivatives of the function with respect to each independent variable.

$$\Delta f = \sum_{i=1}^{n} \frac{\partial^2 f}{\partial x_i^2}$$

3.3.2.4: Walsh-Hadamard transform

The Walsh-Hadamard transform is an example of a generalized class of Fourier transforms. It performs an orthogonal, symmetric, involutional, linear operation on 2^m real numbers (or complex numbers, although the Hadamard matrices themselves are purely real).

The Hadamard transform Hm is a $2^m \times 2^m$ matrix, the Hadamard matrix (scaled by a normalization factor), that transforms 2^m real numbers x^n into 2 real numbers X^k. The Hadamard transform can be defined in two ways: recursively, or by using the binary (base-2) representation of the indices n and k.

Recursively, we define the 1×1 Hadamard transform H_0 by the identity $H_0 = 1$, and then define H_m for $m > 0$ by:

$$H_m = \frac{1}{\sqrt{2}} \begin{pmatrix} H_{m-1} & H_{m-1} \\ H_{m-1} & -H_{m-1} \end{pmatrix}$$

We got,

$$H_0 = +1$$

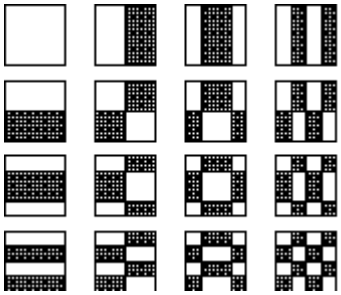
$$H_1 = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$$

$$H_2 = \frac{1}{2} \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{pmatrix}$$

$$H_3 = \frac{1}{2^{\frac{3}{2}}} \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{pmatrix}$$

$$(H_n)_{i,j} = \frac{1}{2^{\frac{n}{2}}} (-1)^{i \cdot j}$$

By applying the transformation, we obtain basis images.



3.3.2.5: Local Power Spectrum Slope (LPS)

Given a function

$$S(u,v) = \frac{1}{N^2}|I(u,v)|^2$$

By representing the two-dimensional frequency in polar co-ordinates, i.e., u = f cosμ and v = f sinμ, and construct S(f;μ). According to [3, 9], by summing the power spectra S over all directions μ, S(f), using polar coordinates, can be approximated by

$$S(f) = \sum_{\theta} S(f,\theta) \simeq A/f^{-\alpha}$$

Where A is an amplitude scaling factor for each orientation and α is the frequency exponent, called slope of power spectrum.

So we look into different function of S(u,v) including,

- Discrete Fourier Transform

discrete Fourier transform (DFT) converts a finite list of equally-spaced samples of a function into the list of coefficients of a finite combination of complex sinusoids, ordered by their frequencies, that has those same sample values. It can be said to convert the sampled function from its original domain (often time or position along a line) to the frequency domain.

The sequence of N complex numbers X_0, ..., X_N−1 is transformed into an N-periodic sequence of complex numbers according to the DFT formula:

$$X_k = \sum_{n=0}^{N-1} x_n \cdot e^{-i2\pi kn/N}.$$

- Discrete Cosine Transform

A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.

The discrete cosine transform is a linear, invertible function $f : \mathbb{R}^N \to \mathbb{R}^N$ (where $\mathbb{R}$ denotes the set of real numbers), or equivalently an invertible N × N square matrix. There are several variants of the DCT with slightly modified definitions. The N real numbers x0, ..., xN-1 are transformed into the N real numbers X0, ..., XN-1 according to one of the formulas:

$$X_k = \frac{1}{2}(x_0 + (-1)^k x_{N-1}) + \sum_{n=1}^{N-2} x_n \cos\left[\frac{\pi}{N-1} nk\right] \qquad k = 0, \ldots, N-1.$$

3.3.2.6: Singular value decomposition

Singular value decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics.

Formally, the singular value decomposition of an *m*×*n* real or complex matrix *I* is a factorization of the form

$$I = \sum_{i=1}^{n} \lambda_i \mathbf{u}_i \mathbf{v}_i^T$$

By summing up certain number of Eigenvalue, and normalize by the sum of Eigenvalue, the significant different between blur and sharp image can be found.

$$\beta 1 = \frac{\sum_{i=1}^{k} \lambda_i}{\sum_{i=1}^{n} \lambda_i}$$

Where λ_i denotes the singular value that is evaluated within a local image patch for each image pixel. As Equation 3 shows, the singular feature is actually the ratio between the first k most significant singular value and all singular values.

** Svd is based on Principal component analysis (PCA), under the assumption that source are Gaussian signals.

3.3.2.7: Independent component analysis

Independent component analysis (ICA) is a computational method for separating a multivariate signal into additive subcomponents supposing the mutual statistical independence of the non-Gaussian source signals. It is a special case of blind source separation.

3.3.3) Test Cases

3.3.3.1 Synthesized Images

- Tesseract test cases

1776 images consist of 16 blocks of sharp images, scan with 300 dpi.

- Simple threshold

2520 images consist of 126 blocks of sharp images, scan with 200 dpi.

3.3.3.2 Real bills

- Real bill threshold finder

24000 images consist of 8 shadow correction bills (5 Megapixels). Crop into 90 images (only text area) and crop into various of patch size (17,22,...,42) then select 200 images with sufficient text pixel.

- Real bill threshold testing

9600 images consist of 1 shadow correction bills (5 Megapixels). Crop into 13 images (only text area) and crop into various of patch size (17,22,...,42) then select 80 images with sufficient text pixel.

3.3.4) Testing Result

3.3.4.1 OCR classification

The first testing approach is based on OCR. By choosing the light-weight OCR, we classify sharp and blur images by passing images into OCR and label as sharp if only the text recognition is correct.

By calculating blur degree or each image with Svd, we calculate the threshold such that generate the best accuracy to classify blur from sharp images. The result table comes with different patch size (20,30,40) and number of Eigen value(1,3,...,9) which is used to sum up.

$$\text{Accuracy} = \frac{tp + tn}{tp+tn+fp+fn}$$

where: tp (true positive) is number of sharp images which are classified as sharp.
tn (true negative) is number of blur images which are classified as blur.
fp (false positive) is number of blur images which are classified as sharp.
fn (false negative) is number of sharp images which are classified as blur.

3.3.4.2 Svd testing on simple threshold finder test cases

By using Svd on simple threshold finder test cases, we found the threshold for best accuracy, specificity, and sensitivity.

$$\text{Sensitivity} = \frac{tp}{tp+fn} \qquad \text{Specificity} = \frac{tn}{tn+fp}$$

where: tp (true positive) is number of sharp images which are classified as sharp.
tn (true negative) is number of blur images which are classified as blur.
fp (false positive) is number of blur images which are classified as sharp.
fn (false negative) is number of sharp images which are classified as blur.

The aim of using sensitivity and specificity are to find the best threshold that let many sharp images pass (flexible system) and the best threshold that block almost every blur images (sensitive system).

3.3.4.3 Svd testing on real bill threshold finder test cases

After we found a promising result for synthesized bills, we run a testing on real bill to find the threshold for the best accuracy.

We apply the testing for patch size 17,22,...,42 aiming to have various option to choose between accuracy and time (the larger patch size, the longer it takes to compile and run).

After we obtain the threshold, we tested them on real bill threshold testing test cases to check the result on other dataset.

3.3.4.4 Svd testing on real bill threshold testing test cases

Rather than finding threshold for the best accuracy, we used threshold from 6.2 to find accuracy on new dataset.

3.3.4.5 Local power spectrum slope testing on real bill threshold finder test cases

We perform a testing for local power spectrum slope algorithm on different patch size, coefficient including,

Linear : $y=Ax+B$; we perform a testing on A

Quadratic : $y= Ax^2+Bx+C$; we perform a Testing on A and B

3.3.4.6 Independent component analysis testing on real bill threshold finder test cases

We perform a testing for ICA on different patch size, Kurtosis parameter, direction of summing including,

patch size : 17,22,...,42

Kurtosis parameter : -1,0,+1

direction of summing : forward (sum up the first n value), backward (sum up the rest from n value)

3.3.5) Resul Analysis

3.3.5.1 Edge detection approach

By applying gradient, Laplacian, Or Walsh-Hadamard Transform will produce quite the same result to edge detection algorithm. These algorithms will work on simple test cases with certain font size, and font type.

By looking into different font size, the larger size will has large relevant area inside the text itself. After we apply these algorithms, we found the edge as very sharp, the area near text as sharp/blur and areas inside text are classified as blur.

3.3.5.2 Local power spectrum slope

The research on Local power spectrum slope focused on natural scene images. By plotting the local power spectrum graph, we found that document images aren't following the trend of linear.

So we try to fit quadratic line instead of linear, and run the experiment on coefficient of linear and quadratic. The result is a failure.

3.3.5.3 Singular value decomposition

The Testing result produces high accuracy, but we have 2 parameters to calibrate including,

- patch size

  Accuracy will rise up as the patch size increase, but need more time to compile and run.

- number of Eigenvalue

  Accuracy will rise up as the number of Eigenvalue increase, but the threshold will rise up.

3.3.5.4 Independent component analysis

The Testing result produces high accuracy with certain parameters, we need to carefully choose the patch size and number of parameter to sum up.

3.3.6 Svd Optimization

By observing compile and run time with size of image patch, we found a relevant connection between each parameter. We run the test using cvSvd() in opencv2.3.

If we take patch size 70x70, we need 0.65 second to complete the detection. Suppose we take that 1000x1000 pixels image and find blur map, we will obtain 1000-70 = 930 pixels blur map. We need 930x930x0.65 = 562185 second = 156.1625 hour to detect 1 image.

3.3.6.1 Quantization

The simplest idea is to quantitize blur map, instead of calculating every pixel.

3.3.6.2 Maximum root approximation

We look closely into the process of Eigenvalue calculation, and found that the equation itself is polynomial. Suppose we choose to use only first Eigenvalue, the root we need to find is E_1 / sum of E

Suppose we define equation as $ax^n+bx^{n-1}+...$, sum of root (or E) can be found by -b/a. The problem is how to find E_1 (maximum root). One of the solution is Graeffe's method.

Graeffe's Method

The method proceeds by multiplying a polynomial $f(x)$ by $f(-x)$ and noting that

$$f(x) = (x-a_1)(x-a_2)\cdots(x-a_n) \quad (1)$$

$$f(-x) = (-1)^n (x+a_1)(x+a_2)\cdots(x+a_n) \quad (2)$$

so the result is

$$f(x)f(-x) = (-1)^n \left(x^2-a_1^2\right)\left(x^2-a_2^2\right)\cdots\left(x^2-a_n^2\right). \quad (3)$$

repeat ν times, then write this in the form

$$y^n + b_1 y^{n-1} + \ldots + b_n = 0 \quad (4)$$

where $y \equiv x^{2^\nu}$. Since the coefficients are given by Vieta's formulas

$$b_1 = -(y_1 + y_2 + \ldots + y_n) \quad (5)$$

$$b_2 = (y_1 y_2 + y_1 y_3 + \ldots + y_{n-1} y_n) \quad (6)$$

$$b_n = (-1)^n y_1 y_2 \cdots y_n, \quad (7)$$

and since the squaring procedure has separated the roots, the first term is larger than rest. Therefore,

$$b_1 \approx -y_1 \quad (8)$$

$$b_2 \approx y_1 y_2 \quad (9)$$

$$b_n \approx (-1)^n y_1 y_2 \cdots y_n, \quad (10)$$

giving

$$y_1 \approx -b_1 \tag{11}$$

$$y_2 \approx -\frac{b_2}{b_1} \tag{12}$$

$$y_n \approx -\frac{b_n}{b_{n-1}}. \tag{13}$$

Solving for the original roots gives

$$a_1 \approx \sqrt[2^v]{-b_1} \tag{14}$$

$$a_2 \approx \sqrt[2^v]{-\frac{b_2}{b_1}} \tag{15}$$

$$a_n \approx \sqrt[2^v]{-\frac{b_n}{b_{n-1}}}. \tag{16}$$

This method works especially well if all roots are real.

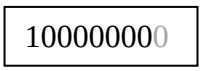
3.3.6.3 Bypass square root step

Svd calculation apply square root to Eigenvalue in the last step. We can ignore this step since taking square root or not will produce the same trend of graph with different scale.

3.3.7) Text Detection

Since we can't separate between blur and background, we need to classify foreground from the background.

Suppose we're interesting in payment amount, if the last digit is blurred and we classify it as background, the payment amount will be incorrect and we'll be sued.



We propose a simple foreground/background separation algorithm using 4 property of foreground including,

- intensity : foreground usually has lower pixel value.
- gradient : foreground usually has higher gradient value.
- Laplacian : foreground usually has higher Laplacian value.
- median filter : by subtract the original image with the same image with median filter, foreground usually has higher value.

We combine the property by clustering all of the property into 2 region with shortest distance between points in the same region, and longest distance between points in different region.

Then we apply dilation to make sure that foreground area cover all of the information we need to pass to OCR. Since we only need rough text detection to guarantee that the area will cover all of the text, the algorithm satisfies the requirement.

3.3.8) Reference

Internet Source

- http://en.wikipedia.org/wiki/Image_gradient
- http://en.wikipedia.org/wiki/Laplace_operator
- http://en.wikipedia.org/wiki/Gaussian_blur
- http://homepages.inf.ed.ac.uk/rbf/HIPR2/gsmooth.htm
- http://users.ecs.soton.ac.uk/km/teachinlg/compression/
- http://www.cse.cuhk.edu.hk/leojia/all_final_papers/blur_detect_cvpr08.pdf
- http://en.wikipedia.org/wiki/Discrete_Fourier_transform
- http://www.ling.ohio-state.edu/~kbaker/pubs/Singular_Value_Decomposition_Tutorial.pdf
- http://en.wikipedia.org/wiki/Singular_value_decomposition
- http://perso.uclouvain.be/michel.verleysen/papers/eusipco05jl.pdf
- http://mathworld.wolfram.com/GraeffesMethod.html

-http://www.infosys.com/about/pages/index.aspx

Research Paper

[1] B. Baker. Blur Detection for Historical Document Images. Family History Technology Workshop. 2012

[2] Berna Erol, Emilio Antúnez and Jonathan J. Hull. HOTPAPER: multimedia interaction with paper using mobile phones. pp.399-408. 16th ACM international conference on Multimedia 2008

[3] Su Bolan. Document Image Enhancement. International Conference on Document Analysis and Recognition. Doctoral Consortium. 2011

[4] Rafael Dueire Lins, Serene Banergee and Marcelo Thielo. Automatically detecting and classifying noises in document images. ACM Symposium on Applied Computing. pp. 33-39. 2010

[5] Seyfollah Soleimani, Filip Rooms and Wilfried Philips. Blur Estimation for Document Images. (2009) Annual Workshop on Circuits, Systems and Signal Processing, 20th, Proceedings. p.285-288

[6] Hsiao, D. Y.;Pei, S. C.;Fuh, C. S. 2004. Localized Blur Estimation on Photography Images and Applications, IPPR Conference on Computer Vision, 2004

[7] Renting Liu, Zhaorong Li and Jiaya Jia. 2008. Image partial blur detection and classification. Computer Vision and Pattern Recognition, pp. 1-8 2008.

[8] De Bock, Yannick, Vincent Spruyt, and Alessandro Ledda. Motion Blur Estimation for Enhancing Visual Tracking. Master's Thesis, 2011-2012

[9] Bolan Su, Shijian Lu and Chew Lim Tan. 2011. Blurred Image Region Detection and Classification. Proceedings of the 19th ACM international conference on Multimedia, pp. 1397-1400, November 2011.

4 Conclusion

4.1) Benefits of Internship

• Received the basic knowledge for engineering job.

• Learnt the principles of teamwork.

• Understanding of risk management in engineering job.

• Learnt the principles of engineering management.

• Understanding of role of engineer in society.

• Learnt the procedures to adapt the knowledge into the real world problems

• Learnt the research approach which will be useful in M.S. and Ph.D Program.

• Learnt to write a research paper.

• Enhanced coding skill in OpenCv, c++, Matlab, AutoIt.

• Learnt to adapt to the foreign society.

• Received an opportunity to meet with successful people.

• Made a connection with foreign people.

• Gain Confidence.

• Narrowed down the list of my potential career.

• Enhanced perspective.

4.2) Problems and Suggestions

Instep program might be one of the best internship opportunities in the whole world. Everything is quite perfect. I cherish the valuable experience, which received from here.

5 Appendix

5.1) Infosys Limited - Location

5.2) Diary Work

ศูนย์บริการจัดหางาน คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

Placement Service Centre , Faculty of Engineering , Chulalongkorn University

อนนพญาไท แขวงวังใหม่ เขตปทุมวัน กรุงเทพฯ 10330 โทร. 0-2218-6303 โทรสาร 0-2252-2687

Student's name : Noranart Vesdapunt ID No : 5330558521 Department : Computer Engineering

Company's name : Infosys Limited

Address : Plot No. 44, Hosur Road, Electronics City, Bengaluru, Karnataka, 560100 India

D/M/Y	Hours	Diary work (abstract)	Student's Signature
18/3/2013	9:15	- Introduced to the team. - Given the information about digital image processing project.	Noranart
19/3/2013	9:15	- Understood the highly detail of the blur detection project	Noranart
20/3/2013	9:15	- Researched and designed blur detection algorithms.	Noranart
21/3/2013	9:15	- Research and implemented blur detection algorithms. - Gathered sample dataset. - Analyzed shadow correction algorithm.	Noranart
22/3/2013	9:15	- Completed the formal induction.	Noranart
25/3/2013	9:15	- Hands on with OpenCv - Capturing project requirement.	Noranart
26/3/2013	9:15	- Hands on with OpenCv - Completed requirement document	Noranart
27/3/2013	9:15	- Research and designed blur detection algorithms.	Noranart
28/3/2013	9:15	- Research and designed blur detection algorithms.	Noranart
29/3/2013	9:15	- Research and designed blur detection algorithms.	Noranart

Total hours in this report : 92:30
Total hours in previous report : -
Total hours : 92:30

I confirm that this report is true

Signature ..... Supervisor Engineer

(… Harikrishna G.N. Rai…..)

Position .....Research Analyst……..

D/M/Y.....27/03/2013.....

แบบ ฟอร์ม EP-02

ศูนย์บริการจัดหางาน คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

Placement Service Centre , Faculty of Engineering , Chulalongkorn University

ถนนพญาไท แขวงวังใหม่ เขตปทุมวัน กรุงเทพฯ 10330 โทร. 0-2218-6303 โทรสาร 0-2252-2687

Student's name : Noranart Vesdapunt ID No : 5330558521 Department : Computer Engineering

Company's name : Infosys Limited

Address : Plot No. 44, Hosur Road, Electronics City, Bengaluru, Karnataka, 560100 India

D/M/Y	Hours	Diary work (abstract)	Student's Signature
1/4/2013	9:15	- implemented blur detection algorithms.	
2/4/2013	9:15	- implemented blur detection algorithms - identified the problems.	
3/4/2013	9:15	- implemented blur detection algorithms. - generated test cases.	
4/4/2013	9:15	- built a report of testing result.	
5/4/2013	9:15	- analyzed the result. - identified the problems.	
8/4/2013	9:15	- generated test cases. - built a report of testing result.	
9/4/2013	9:15	- generated test cases. - built a report of testing result. - identified the problems and further work.	
10/4/2013	9:15	- Research, designed and implemented blur detection algorithms.	
11/4/2013	0	- Chandramana Ugadi (holiday).	
12/4/2013	0	- took a day off.	

Total hours in this report : 74
Total hours in previous report : 92:30
Total hours : 166:30

I confirm that this report is true

Signature ..... Supervisor Engineer

(... Harikrishna G.N. Rai.....)

Position .....Research Analyst.....

D/M/Y 10/04/2013

แบบ ฟอร์ม EP-02

ศูนย์บริการจัดหางาน คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

Placement Service Centre , Faculty of Engineering , Chulalongkorn University

ถนนพญาไท แขวงวังใหม่ เขตปทุมวัน กรุงเทพฯ 10330 โทร. 0-2218-6303 โทรสาร 0-2252-2687

Student's name : Noranart Vesdapunt ID No : 5330558521 Department : Computer Engineering

Company's name : Infosys Limited

Address : Plot No. 44, Hosur Road, Electronics City, Bengaluru, Karnataka, 560100 India

D/M/Y	Hours	Diary work (abstract)	Student's Signature
15/4/2013	9:15	- Implemented blur detection algorithm. - Built visualization tool.	
16/4/2013	9:15	- Implemented blur detection algorithm. - Built visualization tool.	
17/4/2013	9:15	- Researched and implemented blur detection algorithm. - Discussion on result and further works.	
18/4/2013	9:15	- Researched on blur detection algorithm.	
19/4/2013	9:15	- Implemented blur detection algorithm. - Hands on with Matlab.	
22/4/2013	9:15	- Hands on with Matlab. - Discussion on previous algorithm.	
23/4/2013	9:15	- Hands on with Matlab. - Implemented blur detection algorithm. - Generated test cases and reports.	
24/4/2013	9:15	- Implemented blur detection algorithm. - Generated reports.	
25/4/2013	9:15	- Discussion on research approaches. - Generated testing result.	
26/4/2013	9:15	- Generated reports. - Discussion on result and further work.	

Total hours in this report : 92:30
Total hours in previous report : 166:30
Total hours : 259

I confirm that this report is true

Signature ..... Supervisor Engineer

(… Harikrishna G.N. Rai…..)

Position .....Research Analyst……..

D/M/Y.....26 / 04 / 2013.....

แบบ ฟอร์ม EP-02

ศูนย์บริการจัดหางาน คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
Placement Service Centre , Faculty of Engineering , Chulalongkorn University
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Student's name : Noranart Vesdapunt ID No : 5330558521 Department : Computer Engineering

Company's name : Infosys Limited

Address : Plot No. 44, Hosur Road, Electronics City, Bengaluru, Karnataka, 560100 India

D/M/Y	Hours	Diary work (abstract)	Student's Signature
29/4/2013	9:15	- Generated blur maps and plots. - Discussion on result and reason of failure.	Noranart
30/4/2013	9:15	- Generated test cases. - Discussion on result and reason of failure. - Research on optimization method.	Noranart
1/5/2013	9:15	- Research on optimization technic.	Noranart
2/5/2013	9:15	- Research and implement on optimization method. - Research on test cases generation.	Noranart
3/5/2013	9:15	- Research and implement on optimization method. - Discussion on result and further work.	Noranart
6/5/2013	9:15	- Generated test cases. - Built testing framework.	Noranart
7/5/2013	9:15	- Built testing framework. - Generated report.	Noranart
8/5/2013	9:15	- Generated reports. - Generated plots and heat maps. - Researched for improved algorithms.	Noranart
9/5/2013	9:15	- Research on classifier. - Discussion on result and further work.	Noranart
10/5/2013	9:15	- Generated test cases. - Generated report.	Noranart

Total hours in this report : 92:30
Total hours in previous report : 259
Total hours : 351:30

I confirm that this report is true

Signature ..... Supervisor Engineer

(... Harikrishna G.N. Rai.....)

Position .....Research Analyst.....

D/M/Y..... 09 / 05 / 2013

แบบ ฟอร์ม EP-02

ศูนย์บริการจัดหางาน คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
Placement Service Centre , Faculty of Engineering , Chulalongkorn University
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Student's name : Noranart Vesdapunt ID No : 5330558521 Department : Computer Engineering

Company's name : Infosys Limited

Address : Plot No. 44, Hosur Road, Electronics City, Bengaluru, Karnataka, 560100 India

D/M/Y	Hours	Diary work (abstract)	Student's Signature
13/4/2013	0	- took a day off	
14/4/2013	9:15	- Generated test cases. - Research on clustering.	
15/5/2013	9:15	- Research on blur detection algorithm. - Generated report. - Discussion on research paper.	
16/5/2013	9:15	- Research on blur detection algorithm. - Generated reports.	
17/5/2013	9:15	- Built testing framework - Fixed error test cases. - Discussion on research paper.	
20/5/2013	9:15	- Built testing framework - Generated reports.	
21/5/2013	9:15	- Testing on blur detection algorithm. - Generated report.	
22/5/2013	9:15	- Wrote documentation	
23/5/2013	9:15	- Wrote documentation	
24/5/2013	9:15	- Wrote documentation	

Total hours in this report : 83:15
Total hours in previous report : 351:30
Total hours : 434:45

I confirm that this report is true

Signature ..... Supervisor Engineer

(... Harikrishna G.N. Rai.....)

Position .....Research Analyst.....

D/M/Y.....24-MAY-2013.....

แบบ ฟอร์ม EP-02

ศูนย์บริการจัดหางาน คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
Placement Service Centre , Faculty of Engineering , Chulalongkorn University
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Student's name : Noranart Vesdapunt ID No : 5330558521 Department : Computer Engineering

Company's name : Infosys Limited

Address : Plot No. 44, Hosur Road, Electronics City, Bengaluru, Karnataka, 560100 India

D/M/Y	Hours	Diary work (abstract)	Student's Signature
27/4/2013	9:15	- Wrote documentation - Preparation for final presentation	Noranart
28/4/2013	9:15	- Wrote documentation - Preparation for final presentation	Noranart
29/5/2013	9:15	- Wrote documentation - Final presentation	Noranart
30/5/2013	9:15	- Wrote documentation - Completed leaving formalties.	Noranart
31/5/2013	9:15	- Wrote documentation - Completed leaving formalties.	Noranart

Total hours in this report : 46:15
Total hours in previous report : 434:45
Total hours : 481

I confirm that this report is true

Signature ..... Supervisor Engineer

(… Harikrishna G.N. Rai…..)

Position .....Research Analyst……..

D/M/Y.....31/05/2013.....

แบบฟอร์ม EP-02