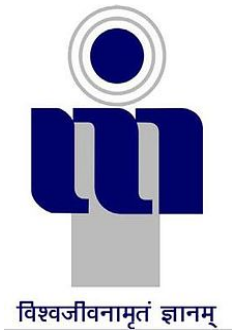
Tomography Image Super Resolution

M.Tech Thesis Research Proposal



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1 Problem Statement

In medical imaging, there is always a challenge of getting sharp images because of complexity involved in human anatomy. As a result, the images produced by techniques like tomography are of low resolution, which can lead to poor medical decision or delay in some cases. So image enhancement in medical images is of great practical value. But the classical image enhancement techniques don't work well with medical images. Image Super Resolution, the process of recovering high resolution images from low resolution images can overcome these limitations. Studies on CNN have shown promising results for Image Enhancement. So, the idea is to propose CNN model based on Generative Adversarial Networks which will help to enhance the quality of the medical images and make it more reliable.

2 Existing Research Works

Following are some research works that focuses on the similar issues

- **Christian Ledig, Lucas Theis, Ferenc Huszár, Jose Caballero, Andrew Cunningham and Alejandro Acosta** [4] presents a deep residual network that is able to recover photo-realistic textures from heavily down sampled images on public benchmarks. In this paper, they present SRGAN, a generative adversarial network (GAN) for image super-resolution (SR).
- **Quan Do, Sebastian Acuna, Jon Ivar Kristiansen, Krishna Agarwal and Phuong Hoai Ha 2021** [9] proposes multiple signal classification algorithm(MUSICAL) for wide-field fluorescence microscopy. This paper aims to analyze the performance and scalability of MUSICAL for improving its low computational performance and explains how it can be speed-up to 30 times by developing a new parallel MUSICAL in C++ using Intel Threading Building Blocks.
- **Koki Yamashita and Konstantin Markov 2020** [8] aims at enhancing optic nerve head images obtained by Optical Coherence Tomography (OCT). However, instead of directly applying noise reduction techniques, they use multiple state-of-the-art image Super-Resolution (SR) methods such as super-resolution Convolutional Neural Network (SRCNN), very deep Convolutional Network (VDSR),

deeply recursive Convolutional Network (DRCN), and enhanced super-resolution Generative Adversarial Network (ESRGAN)

- **Ziyi Shen, Huazhu Fu, Jianbing Shen and Ling Shao 2021 [10]** highlights the drawbacks low quality Retinal fundus images and proposes a clinically oriented fundus enhancement network (cofe-Net) to suppress global degradation factors. They also show that the fundus correction method can benefit medical image analysis applications, e.g., retinal vessel segmentation and optic disc/cup detection.

- **Honggang Yu, Carla Agurto, Simon Barriga, Sheila C. Nemeth, Peter Soliz and Gilberto Zamora [1]** present a system that can automatically determine whether the quality of a retinal image is sufficient for computer-based diabetic retinopathy (DR) screening. The system integrates global histogram features, textural features, and vessel density, as well as a local non-reference perceptual sharpness metric.

- **Wanghu Chen, Bo Yang, Jing Li, and Jianwu Wang 2020 [7]** explains limitations of Deep CNN because of time taken to train and overfittng and discuss an approach to retinal image classification based on the integration of multi-scale shallow CNNs.

- **Chao Dong, Chen Change Loy, Kaiming He, Xiaoou Tang [3]** propose a deep learning method for single image super-resolution (SR). Their method directly learns an end-to-end mapping between the low/high-resolution images with a lightweight deep CNN structure, yet demonstrates state-of-the-art restoration quality, and achieves fast speed for practical on-line usage.

- **V. Anoop and P. R. Bipin 2020 [6]** proposed the fundus image with Super-Resolution and its performance via the Diagnostically Significant Area (DSA). This approach focuses only on the region of Interest (ROI) instead of concentrating on the entire image leading to less computational time by reducing the time complexity.

- **Changhui Jiang, Qiyang Zhang, Rui Fan and Zhanli Hu [5]** proposes a single-computed tomography (CT) image super-resolution (SR) reconstruction scheme. This SR reconstruction scheme is based on sparse representation theory and dictionary learning of low and high-resolution image patch pairs to improve

the poor quality of low-resolution CT images obtained in clinical practice using low-dose CT technology.

- **Jithin Saji Isaac and Ramesh Kulkarni [2]** details few of the types of medical imaginary, various techniques used to perform super resolution and the current trends which are being followed for the implementation of this concept.

Comparision of the literature reviews

Table 1: Table represents the comparision of the literature reviews in various aspects

S. No.	Title of paper	Author	Methodology	Limitations	Dataset	Evaluation Results
1	Highly Efficient and Scalable Framework for High-Speed Super-Resolution Microscopy	Quan Do, Sebastian Acuna, Jon Ivar Kristiansen, Krishna Agarwaland Phuong Hoai Ha	Generative adversarial network (GAN)	High end GPU is needed for high-performance parallel programming	Sample acquired using a high-speed camera	Speed: 30.43× Matlab 2.63× Java 1.69× Python
2	Medical Image Enhancement Using Super Resolution Methods	Koki Yamashita and Konstantin Markov	Super-resolution Convolutional Neural Network (SRCNN), Very deep Convolutional Network (VDSR), Deeply recursive Convolutional Network (DRCN)	Larger training time, needs to design loss function	350 OCT scans	a)PSNR: 25.23 b)SSIM: 0.798
3	Modeling and Enhancing Low-Quality Retinal Fundus Images	Ziyi Shen, Huazhu Fu, Jianbing Shen and Ling Shao	clinicallyoriented fundus enhancement network (cofeNet)	-	EyeQ and DRIVE dataset	a)PSNR: 21.24 b)SSIM: 0.758
4	Automated image quality evaluation of retinal fundus photographs in diabetic retinopathy screening	Honggang Yu, Carla Agurto, Simon Barriga, Sheila C. Nemeth, Pe-ter Soliz and Gilberto Zamora	Integrates global histogramfeatures, textural features, and vessel density,	requires image registration for some datasets	BRATS datasets	a)SSIM: 0.756 b)PSNR: 20.94

5	An Approach to Detecting Diabetic Retinopathy Based on Integrated Shallow Convolutional Neural Networks	Wanghu Chen, Bo Yang, Jing Li, and Jianwu Wang	Integration ofmulti-scale shallow CNNs	Can be trained on anonymized data sets allowing for sharing of training data	ADNI and BRATS datasets	PSNR: 25.43
6	Image Super-Resolution Using Deep Convolutional Networks	Chao Dong, Chen Change Loy, Kaiming He, Xiaoou Tang	A deep learning method for single image super-resolution	-	EyeQ dataset	a)PSNE: 1.4 $\pm$ 0.4
7	Photo-Realistic Single Image Super-Resolution Using a Generative Adversarial Network	Christian Ledig, Lucas Theis, Ferenc Husz ar, Jose Caballero, AndrewCunningham and Alejandro Acosta	GAN based framework	-	REFUGE dataset	PSNR: 28.51
8	Super-Resolution Based Automatic Diagnosis of Retinal Disease Detection for Clinical Applications	V. Anoop and P. R. Bipin	Generative adversarial network (GAN)	-	STARE dataset	a)PSNR: 64.72 dB b)Diagnostically Significant Area (DSA)
9	Super-resolution CT Image Reconstruction Based on Dictionary Learning and Sparse Representation	Changhui Jiang, Qiyang Zhang, Rui Fan and Zhanli Hu	Sparse representation theory and dictionary learning of low and high-resolution image	DC layers can only learn relative consistent and local deformations	IXI and Private abdominal dataset	a)MSE: 0.044 b)PSNR: 22.72 c)SSIM: 0.796
10	Super resolution techniques for medical image processing	Jithin Saji Isaac and Ramesh Kulkarni	Single-image super resolution	Enhancing spatial resolution i.e Interpolation can result in unpleasant artifacts and introduce noise	Same organ and same modality LR images	PSNR: 24.23

3 Limitations of Existing Research

Although the research work listed above had played an important role in areas of Image Super Resolution and Medical Imaging but there are certain limitations which allow more detailed research to be performed such as.

- Classical image enhancement techniques don't work well with medical images because of complexity of Human Anatomy. Enhancing spatial resolution i.e Interpolation can result in unpleasant and jaggy artifacts [2].
- They work with straightforward techniques disregarding the fact that more than one shallow CNN can be used to improve performance [7].

There are few more research work have been done which claims very promising results but they do so at the cost of computational time, making them difficult to utilise [3].

4 Objectives & Evaluation Parameters

To make the Medical Imaging more reliable, I propose a multi-scale shallow CNN with Performance Integration based on Generative Adversarial Network that can generate the Super Resolution Images which qualifies for medical decision making process.

To evaluate the results I propose using Tomography Image Super Resolution and its performance effect on Retinal Disease Classification.

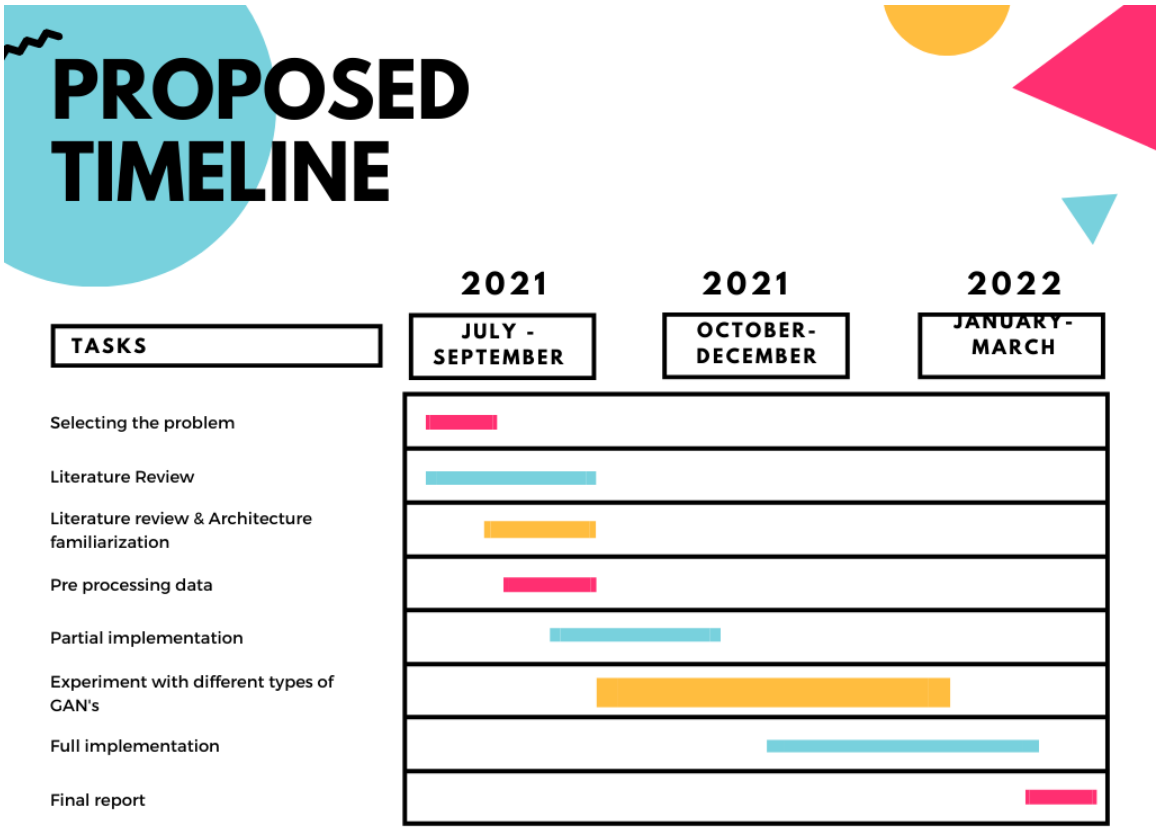

Figure 1: Timeline for Project completion(Gantt Chart)

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