NIRMA UNIVERSITY

MINOR RESEARCH PROJECT

Automatic Marksheet Generation through Handwritten Character Recognition

PI: Prof. Rutul Patel

EC, IT- NU

Co-PI: Prof. Bhavin Kakani

EC, IT- NU

NU/DRI/MinResPrj/IT/2019-20/

Date: 02/03/2020

To,
Prof. Rutul Patel - Principal Investigator
Assistant Professor,
Department of Electronics and Communication Engineering
Institute of Technology, Nirma University

Prof. Bhavin Kakani – Co- Principal Investigator
Professor, Department of Electronics and Communication Engineering
Institute of Technology, Nirma University

Dear, Prof. Rutul Patel & Prof. Bhavin Kakani,

With pleasure, I would like to inform you that the Director General, NU has approved your Minor Research Project titled **"Automated Marksheet Generation through Handwritten Character Recognition".** subject to following:

(i) Submission of atleast one research paper in a SCOPUS indexed journal. The paper must be submitted to the journal within one year after the completion of the project and the same must be intimated to the DRI.

(ii) Involvement of UG/ PG Students in relevant activities of the research project. The financial assistance of Rs. 57,000/- is sanctioned subject to approval of budget under E1A43F for Financial year 2020-2021 for Institute of Technology. The period will start from 1st April 2020. You will be governed by the NU prescribed Minor Research Project guidelines and the conditions as below:

1. You will complete the Project by 31st March 2021. No case extension will be granted.
2. Adhere to the financial assistance is as below mentioned budget head:

Budget Head	Amount Sanctioned
Equipments & Accessories	37,000
Books and Journals	5,000
Contingencies	5,000
Chemicals, Glassware and Consumables	10,000
Total	**57,000/-**

3. For monitoring the progress of the Minor Research Project, it is also required to have progress report by the end of every six months. Further release of reimbursement / grant will be subject to submission of the progress report. The report is to be submitted to the Director General, NU (through proper channel) after examination of the same by the Committee (constituted at institute level at the time of submitting the proposal).

4. On completion of the project, the PI will prepare a Final Projector Report and submit the same to DRI maximum within one month from the project completion date.

This is for your information and further action.

Director (DR&I)

C.C: HoI-concerned,, HoD-concerned, Chief Accounts Officer–NU,O.S.–IT,NU, Internal Auditor.

Annexure I

Proforma for Applying for Nirma University Funded Minor Research Project

1.	**Project Title:**	Automated Marksheet Generation through Handwritten Character Recognition
2.	**Project Duration:**	12 months
3.	**Project Objectives:**	To create a standalone Vision-based hardware for recognizing handwritten marks written on the answerbook
4.	**Project Deliverables:**	Prototype hardware
5.	**Details of the Principal Investigator:**	
	Full Name:	Rutul Patel
	Designation:	Assistant Professor
	Whether confirmed employee of University or on probation:	On probation
	Department / Area, Institute:	ECE department, ITNU
	E-mail:	rutul.patel@nirmauni.ac.in
	Intercom Extension Number:	409
	Cell Phone Number	9033017673
	No. of Other Projects Completed, Ongoing and Submitted:	Nil
6.	**Details of the Co- Principal Investigator (if Applicable):**	
	Full Name:	Bhavin Kakani
	Designation:	Assistant Professor
	Department / Area, Institute:	ECE department, ITNU
	E-mail:	bhavin.kakani@nirmauni.ac.in
	Intercom Extension Number:	421
	Cell Phone Number	9033304411
	No. of Other Projects Completed, Ongoing and Submitted:	Nil
7.	**Details of the Mentor: (if Applicable)**	
	Full Name:	
	Designation:	
	Department / Area, Institute:	
	E-mail:	
	Intercom Extension Number:	
	Cell Phone Number	
8.	**Detailed Project Proposal:**	Yes
9.	**Project Plan (Pert Chart):**	Yes
10.	**Budget Requirements (in Rs.):**	
	Equipment and Accessories:	37,000
	Books and Journals:	5,000
	Software:	Nil
	Hiring Services:	Nil

	Contingencies:	5,000
	Chemicals, Glassware and Consumables:	10,000
	Travel for Field Work:	Nil
11.	**Budget Bifurcation (in Rs.):**	
	1st Quarter Budget Requirements (in Rs.):	26,000
	2nd Quarter Budget Requirements (in Rs.):	14,000
	3rd Quarter Budget Requirements (in Rs.):	10,000
	4th Quarter Budget Requirements (in Rs.):	7,000
12.	**Total Allocated Budget for the Minor Research Project to the Institute**	57,000
13.	**Amount Sanctioned till date from the Allocated Institute Budget**	

Signature of Applicant(s)

Through:

HoD / Area Chair Concerned

HoI Concerned

Annexure II

Assessment Certificate

(To be submitted by the Committee with the Research Proposal)

It is certified that the research proposal titled, "**Automatic Marksheet Generation through Handwritten Character Recognition**" submitted by Prof. **Rutul Patel** of Dept. of **Electronics and communication Engineering**, Institute of **Technology** has been assessed by the Committee consisting of the following members for submission to Nirma University for financial support under the scheme of Minor Research Projects.

Details of Expert Committee (Name and Designation):
1. Dr. D. A. Pujara (HOD, EC dept, IT-NU)
2. Dr. N. P. Gajjar (Professor, EC dept, IT-NU)
3. Dr. Manisha Upadhyay (Associate Professor, EC dept, IT-NU)

Suggestions / Comments:
1. Committee has suggested to incorporate literature review in support to the Minor Research Proposal.
2. The rest of the content was satisfactory and committee members consider that it be a useful project and recommend to forward it for further consideration.

The proposal is as per the guidelines.

Signed by:

Committee Members:

Dr. Manisha Upadhyay Dr. N. P. Gajjar Dr. D.A.Pujara

HoD / Area Chair Concerned:

HoI/Dean Concerned:

Annexure IV

Six Monthly Progress Report for Nirma University Funded Minor Research Project

1.	**Project Title:**	Automated Marksheet Generation through Handwritten Character Recognition
2.	**Name of the Principal Investigator:**	Rutul Patel
3.	**Project Approval Letter No. and Date:**	NU/DRI/MinResPrj /IT/2019-20 02/03/2020
4.	**Date of the Project Commencement:**	01/04/2020
5.	**Progress Report No.**	01
6.	**Period of Report:**	
	From (dd/mm/yyyy):	27/07/2020
	Up to (dd/mm/yyyy):	27/12/2020
7.	**Details of the Committee Members (Name, Designation)**	
	Member -1	Dr. Nagendra Gajjar
	Member -2	Dr. Manisha Upadhyay
	Member -3	
	Member -4	
8.	**Details of Fund Utilization:**	
	Total Budget Sanctioned (in Rs.)	57,000/-
	Total Expenditure Incurred (in Rs.)	9,975/-
9.	**Please enclose a summary of the work done so far and results achieved.**	Details are mentioned in the attached report
10.	**Attach copy of the papers published / presented, etc., if any.**	--
11.	**Is the work progress as per the original plan of work and towards achieving the objectives? If not, state reasons.**	Principal Investigator was on Probation period and got confirmed on 27 July 2020.
12.	**Any other Information:**	--

Submitted by:

Prof. Rutul Patel (PI) Prof. Bhavin V Kakani (Co-PI)

Endorsed by:

Committee Members:

Dr. N. P. Gajjar Dr. Manisha Upadhyay

Remarks by the Committee Members:

- Committee suggested to look for the possibility of submitting the work to some renowned Educational Journal.
- Committee appreciated the use of Deep Neural Network for the implementation and suggested to see if the accuracy can be enhanced using any other classification techniques.
- Committee also suggested to utilize the remaining budget to fulfill the objectives of the project.
- Committee also suggest to start working on backend result representation tool/GUI (Excelsheet preparation).

HoD / Area Chair Concerned:

HoD (EC)

HoI/Dean Concerned:

HoI (ITNU)

Annexure V

Proforma for Statement of Expenditure for Nirma University Funded Minor Research Project

1.	**Project Title:**	Automated Marksheet Generation through Handwritten Character Recognition
2.	**Name of the Project Investigator:**	Rutul Patel
3.	**Project Approval Letter No. and Date:**	NU/DRI/MinResPrj /IT/2019-20 02/03/2020
4.	**Period of Expenditure:**	
	From:	01/04/2020
	Up To:	31/03/2021
5.	**Details of Expenditure:**	

Sr. No.	Item	Amount Approved (in Rs.)	Expenses Incurred (in Rs.)
i.	Equipment and Accessories	37,000	35,018
ii.	Books and Journals	5,000	2,815
iii.	Software	NIL	NIL
iv.	Hiring Services	NIL	NIL
v.	Contingencies	5,000	NIL
vi.	Chemicals, Glassware and Consumables	10,000	9,975
vii.	Travel and Field Work	NIL	NIL

As a result of check or audit objection, if some irregularity is noticed at later stage, action will be taken to refund, adjust or regularize the objected amounts.

It is certified that the grant of Rs. Fifty seven thousand received from the University under the Minor Research Project titled, "Automated Marksheet Generation through Handwritten Character Recognition" vide approval Letter No. NU/DRI/MinResPrj /IT/2019-20 dated 02/03/2020 and Rs. Forty seven thousand eight hundred eight has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University.

Submitted by: Prof. Rutul Patel (PI) Prof. Bhavin Kakani (Co-PI)

Verified by:

HoD / Area Chair Concerned

HoI/Dean Concerned

Annexure VI

Proforma for Statement of Expenditure on Field Work for Nirma University Funded Minor Research Project

1.	**Project Title:**	Automated Marksheet Generation through Handwritten Character Recognition
2.	**Name of the Project Investigator:**	Rutul Patel
3.	**Project Approval Letter No. and Date:**	NU/DRI/MinResPrj /IT/2019-20 02/03/2020
4.	**Period of Expenditure:**	
	From:	01/04/2020
	Up To:	31/03/2021
5.	**Purpose of the Field Visit:**	NA
6.	**Details of Expenditure on Field Work:**	

Sr. No.	Name of the Place Visited	Duration of Visit		Mode of Journey	Expenses Incurred (in Rs.)
		From	To		
i.	NA	--		--	--

Certified that above expenditure is in accordance with the norms of Nirma University.

Signed by:

Prof. Rutul Patel (PI) Prof. Bhavin Kakani (Co-PI)

HoD / Area Chair Concerned

HoI/Dean Concerned

Annexure VII

Proforma for the Final Report for Nirma University Funded Minor Research Project

1.	**Project Title:**	Automated Marksheet Generation through Handwritten Character Recognition
2.	**Name of the Principal Investigator:**	Rutul Patel
3.	**Name of the Co- Principal Investigator: (if Applicable)**	Bhain Kakani
4.	**Name of the Mentor (if Applicable):**	--
5.	**Project Approval Letter No. and Date:**	NU/DRI/MinResPrj /IT/2019-20 02/03/2020
6.	**Project Duration:**	01 year
	Date of the Project Commencement	01/04/2020
	Date of the Project Completion	30/06/2021
7.	**Project Objectives:**	• To detect handwritten characters from acquired image • To recognize each handwritten character which represents student's marks • To create a record of a student along with assigned marks in excel
8.	**Total Fund Sanctioned:**	Rs. 57,000/-
9.	**Total Fund Utilized:**	Rs. 47,808/-
10.	**Whether the objectives are achieved or not? (give details)**	All objectives are achieved.
11.	**Summary of Findings / Results:**	Details are mentioned in the report
12.	**Contribution to the Society (give details):**	This projects helps faculty to prepare record of student marks.
13.	**No. of Publications out of the Project:**	Under preparation
14.	**No. of Patents applied for:**	NIL
15.	**Experimental Set-up / Skills developed:**	Python programming on Jetson Nano
16.	**Human Resource Developed:**	NA
17.	**Any Noteworthy Achievements**	--

Signed by:_____ (PI) _____ (Co – PI) _____(Mentor)

Signed by:

Committee Members:

HoD / Area Chair Concerned:

HoI/Dean Concerned:

Annexure VIII

Utilization Certificate

Certified that the grant of Rs. Fifty seven thousand received from the University under the Minor Research Project titled, "Automated Marksheet Generation through Handwritten Character Recognition" vide approval Letter No. NU/DRI/MinResPrj /IT/2019-20 dated 02/03/2020 and Rs. Forty seven thousand eight hundred eight has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University.

Certified that the experimental set-up developed / equipment and accessories purchased are handed over to the department of Electronics and Communication Engineering.

Certified that the Nirma University is acknowledged / will be acknowledged in all the outcomes / publication / patent, etc.

Signed by: _____ (PI) _____ (Co-PI)

Endorsed by:

HoD / Area Chair Concerned:

HoI/Dean Concerned:

Automatic Marksheet Generation through Handwritten Character Recognition

ORIGINALITY REPORT

8%	6%	6%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Bhavin V. Kakani, Divyang Gandhi, Sagar Jani. "Improved OCR based automatic vehicle number plate recognition using features trained neural network", 2017 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2017 Publication	1%
2	mafiadoc.com Internet Source	1%
3	www.linknovate.com Internet Source	1%
4	link.springer.com Internet Source	1%
5	Chamila Liyanage, Thilini Nadungodage, Ruvan Weerasinghe. "Developing a commercial grade Tamil OCR for recognizing font and size independent text", 2015 Fifteenth International Conference on	1%

	Advances in ICT for Emerging Regions (ICTer), 2015 Publication	
6	adityapoojigs.blogspot.com Internet Source	<1 %
7	doaj.org Internet Source	<1 %
8	V N Manjunath Aradhya, G Hemantha Kumar, S Noushath. "Two-Dimensional Matrix Principal Component Analysis Useful for Character Recognition", 2006 International Conference on Information and Automation, 2006 Publication	<1 %
9	www.coursehero.com Internet Source	<1 %
10	"Recent Trends in Image Processing and Pattern Recognition", Springer Science and Business Media LLC, 2019 Publication	<1 %
11	ieeexplore.ieee.org Internet Source	<1 %
12	www.instructables.com Internet Source	<1 %

Exclude quotes	Off	Exclude matches	< 20 words
Exclude bibliography	On		

Rutul Patel <rutul.patel@nirmauni.ac.in>

Closure Report of Minor Research Project

1 message

Nirma University PhD Section <phd.section@nirmauni.ac.in> Tue, Aug 3, 2021 at 11:55 AM
To: Rutul Patel <rutul.patel@nirmauni.ac.in>, Bhavin Kakani <bhavin.kakani@nirmauni.ac.in>
Cc: "Dr. Madhuri Bhavsar" <hod_ce.it@nirmauni.ac.in>

Dear Prof. Rutul Patel & Bhavin Kakani
Greetings!

You have been given financial assistance to carry out a minor research project entitled, “Automated Marksheet Generation through Handwritten Character Recognition". The duration of the project was April-2020 to March-2021 (Extended to July-2021) and the budget utilized was Rs.47,808/- . The Closure Report submitted by you was presented to the competent authority of the University and the report is approved and accepted. However, you are informed to bring to the notice of the office of Director - RI about submission and result of journal paper.

This is for your information.

Thanks

Asst. Registrar

NIRMA UNIVERSITY

MINOR RESEARCH PROJECT

Project Report

Automatic Marksheet Generation through Handwritten Character Recognition

PI: Prof. Rutul Patel

EC, IT- NU

Co-PI: Prof. Bhavin Kakani

EC, IT- NU

Table of Contents

1 Abstract

A digital record of student assessment is a necessity to develop a system for recognizing connected handwritten digit strings using an automatic handwritten digit recognition approach. Segmenting each character from student marksheet is a challenge in presence of complex backgrounds. Further, extraction of region of interest is essential and crucial since it affects recognition accuracy significantly. In this project, we have proposed a prototype system that captures image of student marks and roll number and separate each images. The digits were divided into individual digits in order to complete the recognition process.

The handwritten digit segmentation is performed through vertical and horizontal projected histograms. Each occurring peak index suggests the possible bounding box around the characters. These peaks are further suggesting intermediate boundaries that is essential for segmentation of digits.

A later stage of recognition classifies is segmented digit using developed Convolutional Neural Network (CNN) model trained through widely used MNIST dataset. Such CNN model demands hardware with minimal power consumption, excellent accuracy, and high performance. In high-performance deep learning applications, high-level Graphics Processing Units (GPU) are widely used. Building a high-performance platform, on the other hand, costs a lot of money and consumes significant power. In the proposed system, a single board computer called NVIDIA developed Jetson nano through CNN algorithms are implemented and performance is evaluated. Finally, the embedded system boards' performance in diverse data sets using the CNN method is examined. As a result, it is focused at achieving high accuracy with minimal hardware requirements in deep learning applications.

The developed system can effectively localize and recognize the field entries with a processing time of 10 seconds due to processing of tensor-flow libraries and a recognition rate of 91%, according to experimental data. We've built an efficient model with many convolutions, relu, and pooling layers in this project. The model contains 3 convolutional layer, 2 dense layer and 2 maxpool layer with ReLu activation function. The improved version of the stated model is also applied to improve accuracy but computation time increases.

After recognition, the identified digit is automatically recorded with students identity (Roll No) with course code, semester and marks in the excel spreadsheet in .csv format. Moreover, for verification the acquired image and segmented output is saved in a unique folder.

2 Introduction

This section covers key motivation to carry out this project work and associated objectives. In addition, we will summarize key contributions as part of the project work.

2.1 Motivation

Student assessment plays a vital role in any university which demands highest accuracy for entering marks into spreadsheets done by the faculty. Furthermore, accreditation agencies require Course Outcomes (COs) attained in each course. To evaluate attainment for each course, marks entry for each student has to be done manually by the faculty which is time consuming and prone to error. However, due to recent evolution in Vision based algorithms along with enhanced computational resources, it is possible to recognize handwritten characters written by the faculty. Due to which, manual entry of marks assigned by the faculty will be recorded automatically through a vision-based system. The purpose of the vision-based system is to benefit faculties to save their time and efforts to prepare mark sheets with higher accuracy.

2.2 Key Objectives

The major goal of this thesis is to determine how well the approaches recognize each other. Data must be used for training utilizing machine learning algorithms in order to examine the performance of the approaches. The digit data is then put to the test with the machine learning technique of choice. The specific objective related to problem statement is given below:

- To identify the Region of Interest (ROI) and detect handwritten characters from acquired images taken through digital visual sensor.
- To segment and recognize each handwritten character which represents student's identity and his/her marks
- To maintain a record of a student along with assigned marks through excel entry.

2.3 Methodology

Two methods will be used to conduct this study. The Literature Review is the first research approach, and the Experiment is the second. A literature study is undertaken initially to gain a thorough understanding of the algorithms and techniques that will be utilized to answer the first research question, which is to determine which type of data is required for machine learning methods and data analysis. Because qualitative data obtained from case studies and surveys cannot be used for this experiment method because it involves non-numerical data, quantitative data is employed instead. An experiment is carried out in this study to discover the best suitable machine learning approach among the available methods. An experiment is carried out using CNN as stated in the Abstract. A comparison of the metrics evaluated is done using the findings acquired from the experiment, resulting in CNN being the best approach fit for Documents Images.

2.4 Key contributions

The major goal of this research is to use an effective segmentation method to accurately segment individual characters. Further, to develop a recognition algorithm to recognize handwritten numbers with maximum accuracy. For this proposed project, key contribution is summarized as follows:

- We have proposed an effective segmentation framework that uses vertical and horizontal projections of histogram. Result validates the effectiveness of segmentation model.
- We have developed a deep neural network, a CNN model that is trained with MNIST dataset which gives validation accuracy over 98%.
- We have introduced a record of student marks and report in excel spreadsheet that enables a faculty to find statistics of the course.
- The entire system was developed on Jetson Nano GPU board which is the first attempt to implement such application.

3 Related Study

Prior to the experimental setup and algorithm categorization, one should have a thorough understanding of the concepts that will be used. To acquire a good grasp of the concepts of algorithms used, a literature review is conducted. The goal of conducting a literature review is to obtain insight into data sets and the deployment of various types of classifiers to recognize handwritten digits.

Automatic handwritten character, text or alphabet acknowledgement framework mostly rely upon the sensitivity of the selection of object features and type of classifier utilized. The detailed literature survey is carried out before actual execution of the stated method for the proposed project. There are various features based on matching and categorization techniques implemented by various researchers. Following studies portray the conduct of research work recognition of English phrases in handwritten alphabets.

The authors did research on "Handwritten Word Recognition Using Multi-view Analysis" in their article [1]. This study makes a significant contribution by providing a solution to the challenge of effectively recognizing handwritten words from a small lexicon. In order to get a computational method inspired by the human reading process, the authors created a multiple classifier system that evaluates words from three different approximation levels.

Dinges et al. [2] proposed a method for recognizing the Arabic characters using statistical transform called Gabor wavelet transform and linear Support Vector Machine (SVM) techniques. It is a segmentation based recognition technique that is applicable to identify any handwritten Arabic character. The strategies follow the steps below. Firstly, the segmentation of individual characters is carried out. The overall segmentation is carried out in 2 simple steps. i) Resolving the PAW's overlapping and ii) Word image segmentation. To decide the related components and baselines that overlap a set of heuristics is discovered and formulated. The thin version is derived from the overlapping free image in the work image segmentation. Then an election operation based on heuristics is conducted. The extraction method for features is used in the output. In feature extraction, features based on Gabor filters are extracted. SVM classification is then used to reduce the number of classes to increase the operation time. During training 1000 images were used to train the classifier. Recognition rates are found to differ according to the letters and rate ranges between 43 - 93%.

Hassan and Khan [3] identified Bangla characters using Local Binary Pattern (LBP). Initial pre-processing is done to reduce noise in the image and to increase the image quality. This paper uses a method that uses Gaussian Low pass filter. Next they detected and corrected slant issues using the KSC algorithm. Next they normalized each image to a standard size. For feature extraction they use LBP. After pre-processing, classification of letters is done. This paper uses Euclidean nearest neighbour classifiers with K=1 is used. They use the CMATERdb database. The performance evaluation is done using different types of LBP features (Basic, uniform, simplified). It is seen that the basic LBP achieves the highest accuracy of 96.7%, uniform LBP shows an accuracy of 96.6%, and simplified LBP shows an accuracy of 96.5%.

In [4] the author uses the Open source Tesseract OCR engine for training Tamil OCR models. Initially they prepared a training dataset in 80:20 ratio for Tamil script. Character segmentation is performed using the process of creating the bx files. Each character is assigned with a box file, so that the number of boxes is equal to the number of training characters. Now training is carried out.

Evaluation process for the proposed OCR system is done using 20 scanned images taken from 20 ancient Tamil books and it provides 14031 characters. It is found that 81% of accuracy is obtained using the proposed system.

Traditional approaches for OCR solutions were based on template matching techniques. Mansour and Indira et al. [5] presented the idea of automatic text extraction from number plates using chain code rules. The other more common text extraction was based on statistical and structure features, or trainable classifier [6].

A novel feature set based on transition information in the vertical and horizontal directions of a digit image combined with the famous Freeman chain code is proposed in [7]. Parvez and Mahmoud [8] presented a robust lexicon reduction technique using segment descriptors for Arabic handwritten text. The method segments an Arabic word into graphemes and adaptively generates a descriptor of the presence/absence of dots in those segments. The segmentation algorithm is based on the characteristic of Arabic script, which indicates predictable segmentations of Arabic characters. This in turn results in novel canonical segment descriptors for the lexicon entries.

Shaffie and Elkobrosy [9][10] Presents the novel idea of facial recognition using printed characters using the centre of axis and principal axis method. This study is an investigation of using both K-Nearest Neighbour (KNN) and Random Forest Tree (RFT) classifiers with previously tested statistical features. These features are independent of the fonts and size of the characters. First, a binarization procedure has been performed on the input characters images, and then the main features have been extracted. The features used in this paper are statistical features calculated on the shapes of characters. A comparison between KNN and RFT classifiers has been evaluated. RFT was found to be better than KNN by more than 11 % recognition rate. The effect of different parameters of these classifiers has also been tested, as well as the effect of noisy characters.

In all of these methods, the most common challenge was to design and pick discriminatory characteristics that are invariant to multiple transformations and resilient to noisy environments. DNN-based solutions have emerged as a replacement for traditional solutions. For instance, CNN can extract powerful visual features from raw data samples using different learned filters. The extracted features are invariant to some degree of shift, size, and noise.

Using DNN in recognizing characters is not addressed by many researchers. DNN learns impressive discriminative features that are robust to different variations and achieves high accuracy in OCR [11]. This technique is only limited only to the classes to be used for the training as new classes require a new training model and retraining everything results in new computational complexity.

The authors of the study [12] carried out research on "Handwriting Recognition On Form Document." To classify the characters on the form document, the author employed Freeman Chain Code, which divides a region into nine sub-regions, histogram normalization of chain code as feature extraction, and Artificial Neural Networks.

The authors [13] did research on "Neural Networks for Handwritten English Alphabet Recognition" in the article. They used neural networks to create a system that recognizes handwritten English alphabets. Each letter of the alphabet is represented by binary values in this system, which are fed into a simple feature extraction system, whose output is supplied into the neural network.

The general requirements for a good model should satisfy the maximum following characteristics [14]:

1. Availability of a large dataset.
2. In each target class, the number of samples has to be roughly equal.
3. Each class training sample should have some form of variations in order to be able to distinguish new variants.
4. The architecture chosen for CNN. Using a DNN model in real time applications requires that the time consumed in extracting the features be as small as possible. Very deep DNN is not necessarily the best solution in all cases and may lead to an overfitting problem.

4 Proposed method

The proposed method recognizes handwritten characters through a two-step process: segmentation and recognition. Image segmentation begins with the extraction of the roll number and marks of a student. As a result, we will have two images that represent the student's roll number and marks. Next, individual characters are segmented for each of the images through horizontal and vertical histograms. These segmented characters are given to the trained CNN model for recognition. The CNN model consists of a single layer of convolution kernels and two fully connected layers for classification. This CNN model is trained with a widely used MNIST dataset. MNIST dataset consists of 60,000 grayscale images of the digits 0-9 each of size 28x28.

4.1 Character Segmentation Process

A list of steps to segment images of individual characters that represent student roll number and marks are as follows:

1. Capture an image from a webcam that has student roll numbers and marks.
2. Convert the captured image to grayscale for further processing.
3. Segment the grayscale image in two parts: student roll number and maks.
4. Binarize both segmented images with pre-defined thresholds.
5. Evaluate horizontal and vertical histogram for both binary images,
6. Determine extreme coordinates (x,y) of bounding boxes that includes student roll number and marks.
7. Segment individual images from both images through the indices of peaks observed in the horizontal and vertical histograms.

Image pre-processing, feature extraction, and classification are the three types of methods utilized in character segmentation. They're usually utilized in that order: picture pre-processing makes feature extraction go more smoothly, and feature extraction is required for accurate classification.

1. **Image Processing:** For accurate character prediction, image preparation is critical in the recognition pipeline. Noise removal, image segmentation, cropping, scaling, and other techniques are commonly used. These approaches were mostly employed in our project for picture recognition, but some of them, such as cropping the written letter and scaling it to our input size, were also used.

   Noise is typically introduced during the digital capture and conversion of a picture, making it difficult to determine what is and is not a part of the object of interest. When it comes to character recognition, we want to eliminate as much noise as possible while still maintaining the strokes of the characters, which are crucial for proper classification. This can be accomplished in a variety of ways. Local level processing is a part of it.

   Local pre-processing, according to [15], computes the output value of the pixel in the output image by using a tiny area around the pixel in question in the input image—a mask. This is referred to as filtering. We utilize convolutional masks to scan an image and, hopefully, remove any undesirable noise. Masks are square matrices with elements

encoding the weights of the surrounding area pixels, which are used to compute the pixel's light intensity value.

$$h = \frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$$

$$Typical\ average\ value$$

$$h = \frac{1}{10}\begin{bmatrix}1 & 1 & 1\\ 1 & 2 & 1\\ 1 & 1 & 1\end{bmatrix}$$

$$Centroid\ highlight$$

We employed median filtering, which is a non-linear technique, to preserve character strokes in our project. A median filter replaces the value of a pixel with the median of the intensity of the pixels around it. Figure 1 depicts the outcome.

(a) Original noisy Image

(b) Converted to grayscale

(c) Binarization

(d) Skeletonization

(e) Median filtering with mask 3 x3

Figure 1 Steps of image pre-processing for segmentation

Picture segmentation is the process of dividing an image into segments that have a high link with objects or real-world attributes. Thresholding is probably the simplest picture segmentation approach. Thresholding is the process of separating the foreground, which in our example is a character, from the somewhat monotonous backdrop. This is the same as binarization in a gray-scale image. The input image is transformed based on an image threshold that is chosen. The output pixel $g(i,j)$ is calculated as follows, given an input pixel $f(i,j)$ and a threshold T:

$$g(i,j) = \begin{cases} 1, & if\ f(i,j) \geq T \\ 0, & if\ f(i,j) < T \end{cases} \quad (1)$$

The output of the same is given in figure above (b) and (c).

2. **Feature Extraction:** The quantifiable qualities of observations are the features of input data that are used to analyze or classify these instances of data. The goal of feature extraction is to select significant traits that reliably distinguish instances while remaining independent of one another.

   The choice of a feature extraction approach, according to [16], is arguably the single most essential component in getting excellent recognition performance. There are numerous ways for extracting features from character images, each with its own set of traits, invariance attributes, and character reconstructability. The paper also states that an experimental examination is required to answer the question of which approach is best suited for a certain situation.

   Template matching, deformable templates, unitary image transforms, graph description, projection histograms, contour profiles, zoning, geometric moment invariants, Zernike moments, spline curve approximation, and Fourier descriptors are among the methods described in [16]. We'll go over one of them briefly to show how feature extraction is sometimes done in handwriting recognition.

   Bhavin [17] presented projection histograms in an OCR system in 2017, and they are utilized in character, word, and text line segmentation, as well as detecting if a scanned text page is rotated. Setting each horizontal and vertical "bin" value to the count of pixels in respective rows and columns (Figure 3), we gather the horizontal and vertical projections of an image, where adjoining bins can be merged to make the features scale independent. The projection is, however, subject to rotation and writing style variation. After comparing the two histograms, a dissimilarity measure is calculated, which can be used as a feature vector.

   As previously said, no approach is intrinsically perfect for any given task. Such evaluations would take a long time and are outside the scope of this project. Instead, we'll concentrate on multilayer feedforward neural networks, which may be thought of as a hybrid of a feature extractor and a classifier.

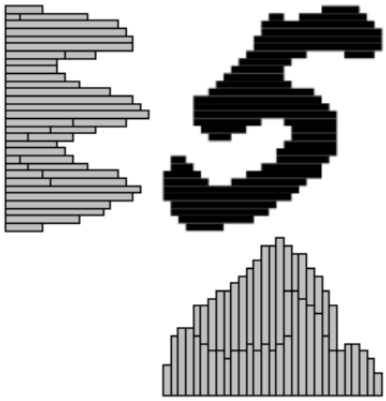


Figure 2 vertical and horizontal projection histogram

Localization: Because the Character Recognition Technique would be unsuccessful if the label and mark position area or Region of Interest (RoI) was not localized, the Localization algorithm must give high accuracy. So we have tried 2 approaches to localize the RoI. First, we tried to localize the rectanguar bounding boxes out of the acquired image, so later through segmentation we can extract those rectangular boxes as mentioned in Figure, but the ML model applied for this problem failed or provided weak output. Moreover, the alightment of the rectangular boxes must be perfectly vertical and horizontal to acquire the complete box.

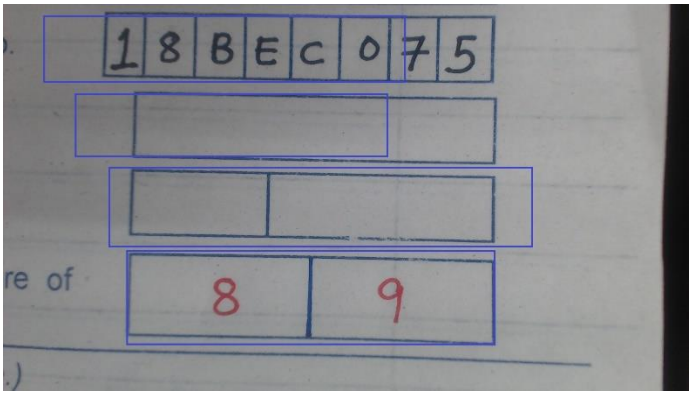


Figure 3 Identifying rectangular boxes on the answer sheet

Localization using projection technique: This is one of the most straightforward methods for analyzing an image. It projects the intensity values on the horizontal x axis and vertical y axis of the image. The image is vertically projected with regard to the y axis in Figure 3. After that, the image is horizontally projected with regard to the x axis. Only the vertical zone, where the magnitude of projection gives the curve, is subjected to horizontal projection. These projections are made using the following set of mathematical formulas:

$$p_x(x) = \sum_{j=0}^{h-1} f(x,j) \quad (2)$$

$$p_y(y) = \sum_{i=0}^{w-1} f(i,y) \quad (3)$$

Where w and h are dimensions of the image.

Vertical band clipping: Vertical and horizontal band clipping use the same mechanism, but the clipping zone varies depending on the image. Vertical band clipping is accomplished by picking a band from the image's vertical projection. In the vertical projection, it is noted that most images with complex backgrounds have three variation curves.

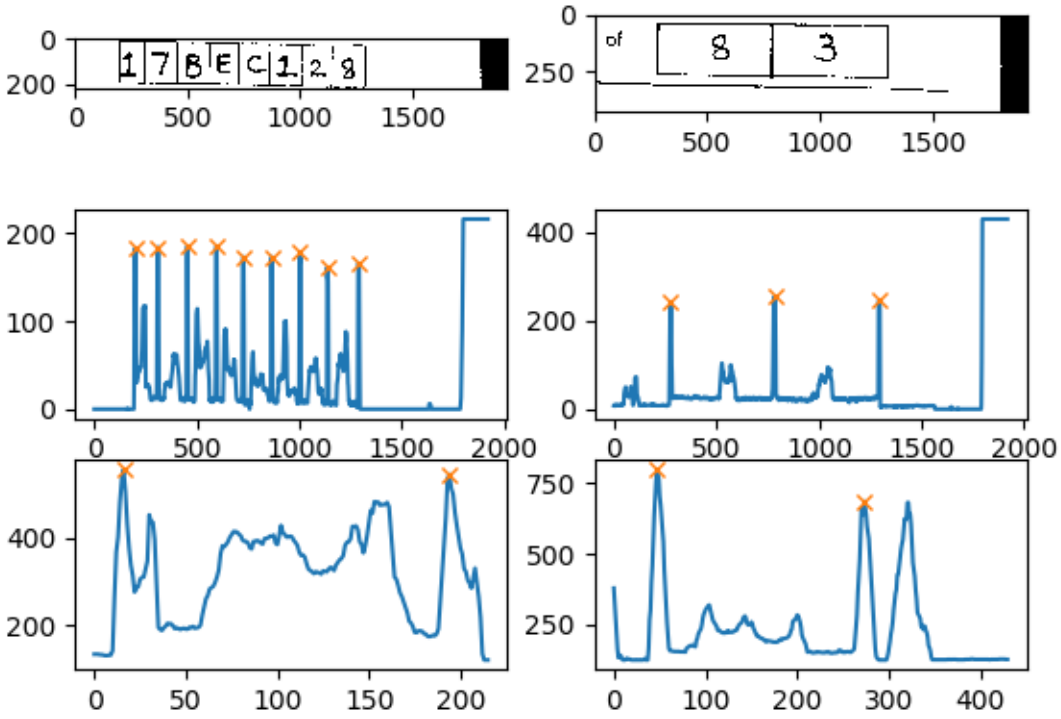


Figure 4 Horizontal and vertical projection histogram of roll number and marks images

4.2 Recognition from handwritten character

A summary of steps to recognize student roll number and marks are as follows:

1. Load an image of a segmented character and convert it into a grayscale image.
2. Invert the previous grayscale image to match compatibility with MNIST dataset images.
3. To achieve better accuracy, enhance the edges of an inverted image using kernel
4. Remove redundant pixels that show salt and paper kinds of noise using the median filter.
5. Predict the class of the pre-processed image through a pre-trained CNN model.
6. Repeat steps 1-5 for each segmented image of roll number and marks.

4.2.1 Character recognition through Convolutional Neural Network (CNN)

Convolutional Neural Networks are similar to regular neural networks in that the data input to the neural network is processed by the convolution layer; they're made up of neurons with learnable weights and biases. Each somatic cell takes some inputs, conducts a scalar product, and optionally executes a non-linearity after that [18]. A CNN is made up of layers, each of which uses a differentiable technique to change one activation into another.

The three basic layers utilized to create CNN architecture are the Convolutional Layer, Pooling Layer, and Fully-Connected Layer. To create a full CNN design, we'll do these levels in order. The special assumptions made by CNN architecture allow us to encode some attributes into architecture. Unit pictures are input for CNN. These make the forward perform more cost-effective to deploy and drastically reduce the amount of parameters in the network [19]. We propose the architecture of CNN model for extracting features from input image and to classify it to most appropriate class. An overview of CNN model for the MNIST dataset classification is shown in Figure 5.

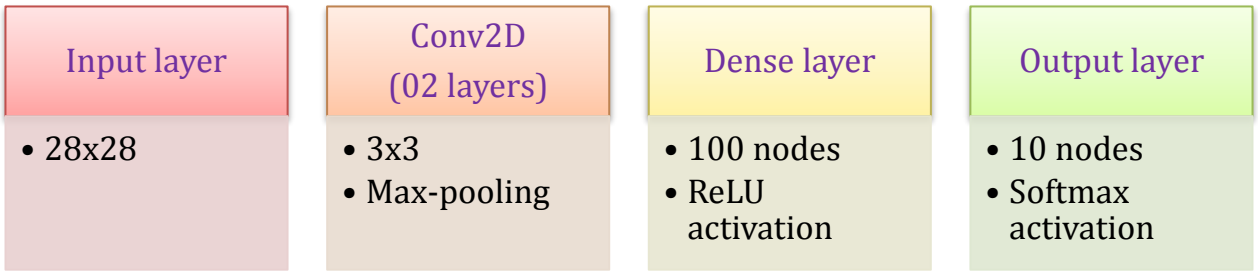


Figure 5 Summary of CNN Model for HCR

The Convolutional Layer's design permits a number of filters that learn and update themselves in order to get the desired outcome. Every filter is a little configuration of space. Move each filter across the input volume throughout the pass and compute dot products between the filter and the input [11]. A two-dimensional activation map is used to represent the value of that particular filter. The filter learns to activate when CNN notices a specific type of visual feature. For each filter in each convolutional layer, a single two-dimensional Activation map is created. The result magnitude can be obtained by stacking the activation maps against the depth of the neurons.

- **ReLu (Rectified Linear Unit) layer**: The term ReLu [20] stands for rectified linear unit. This layer is used to remove negative values from a matrix using the f(x)=max (0,x).
- **Pooling layer**: The Pooling layer is used to reduce the size of the matrix in order to make future computations easier. The max function is the most common function employed in the pooling layer. This function returns the maximum number of filter elements.
- **Fully Connected layer**: Every neuron in one layer communicates with every neuron in the next layer. A fully linked layer is one that has all of its edges connected.

We created a model with four convolutional layers, using 32 5x5 filters in the first two and 64 3x3 filters in the next two. We tried increasing the number of filters in each layer by two, i.e. 32, 64,

128, 256, but the accuracy did not change significantly. Because the image is small, 32 and 64 filters work well. To begin, we reduced the picture in each convolution layer, and there were two convolution layers, but the testing dataset did not provide good accuracy.
The padding was remained the same throughout the process, but the layers were raised to four. After two convolutional layers with strides of two, there were two max-pooling layers, one after the other. They're distorting the image. After each convolutional network, the activation strategy employed is Relu. After a pooling layer, there was a 0.25 dropout. The resultant Matrix was flattened and provided as the input to the fully connected network after the features were removed. Relu and Softmax with a dropout of 0.5 are the activation techniques utilized in the fully connected layer. Because the photos are all grayscale, Relu is the ideal activation function to use.
We tried lowering the learning rate, but found that 0.001 was the best result. By lowering the learning rate and increasing it, the validation accuracy was reduced.
The CNN model is trained with 80% of 60,000 images with the experimental variables as listed in Table 2.

Table 1 Experimental Variables for CNN model

Model variables	**Specifications**
Training dataset	80 %
Testing dataset	20 %
Cross-validation	5-fold
Epochs	10
Batch size	32
Learning rate	0.01

4.2.2 Dataset

On kaggle, the MNIST "Digit Recognizer" dataset has 60000 training images. We used 48000 photos to train our model and 12000 images to validate it. With 10 training epochs and validation epochs, the validation accuracy for the collection of 12000 images we got is 98.45%.

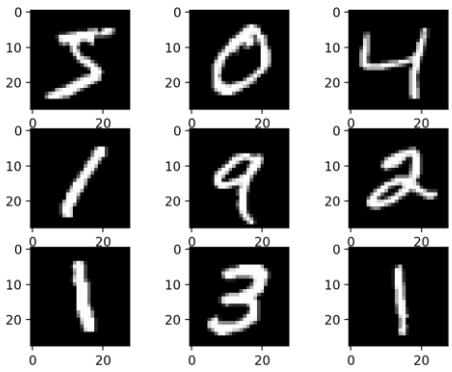


Figure 6 Sample image of MNIST dataset

4.3 Recognition process

In this subsection, we will discuss the simulated CNN model for MNIST dataset for handwritten character recognition. To begin with, we will see an overall flow to recognize handwritten characters as per Figure 1.

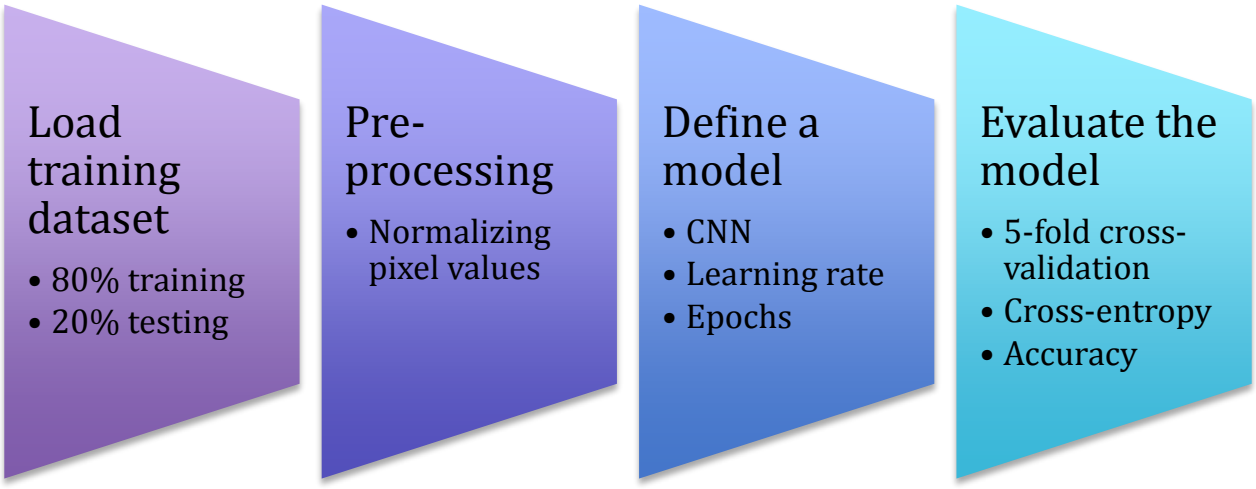


Figure 7 Block diagram of Handwritten Character recognition

4.3.1 Stage – 1 Load training dataset

As shown in Figure 7, first step includes extraction of MNIST Dataset which is divided into training and testing data with proportion of 4:1. The specifications of MNIST dataset is already mentioned in Table 1.

While developing the model for training MNIST handwritten images, we explored many Neural Network models. Convolutional neural network, a complex network, appears to be the greatest fit

because it isolates features before passing them to the fully connected layer. We improved the accuracy of the model by adjusting several parameters such as learning rate, dropout, and the number of epochs. The input testing images are Nirma answer script with the details filled as show in Figure 8.

Figure 8 Sample images for handwritten characters

4.3.2 Stage – 2 Preprocessing

This stage includes normalization of each input grayscale image having pixel values 0 to 255 (Uint8) into 0 to 1. This in turn used for further processing by CNN model for feature extraction and classification. The normalization is performed through pixel-wise operation where each pixel value is divided by maximum value 255.

We employed multiple approaches for segmentation, including the Histogram of the Vertical Projection, Component Analysis, and Segmented Component Analysis, as well as Digit Recognition for recognition. The ability to collect accurate segment information while segmenting handwritten digits such as connected, overlapping, and disconnected digits is a benefit of this system.

4.3.3 Step – 3 Evaluation of a model

The performance of the CNN model is evaluated based on cross-entropy and accuracy. Cross entropy based objective function minimizes difference between Probability Distribution Functions (PDFs). To demonstrate effectiveness of the CNN model, cross entropy and accuracy is evaluated on training and testing dataset with 5-fold cross-validation. The results are shown in Figure 4. Here, blue color line plots represent training dataset cross entropy and accuracy. Whereas, orange color line plots represent testing dataset cross entropy and accuracy.

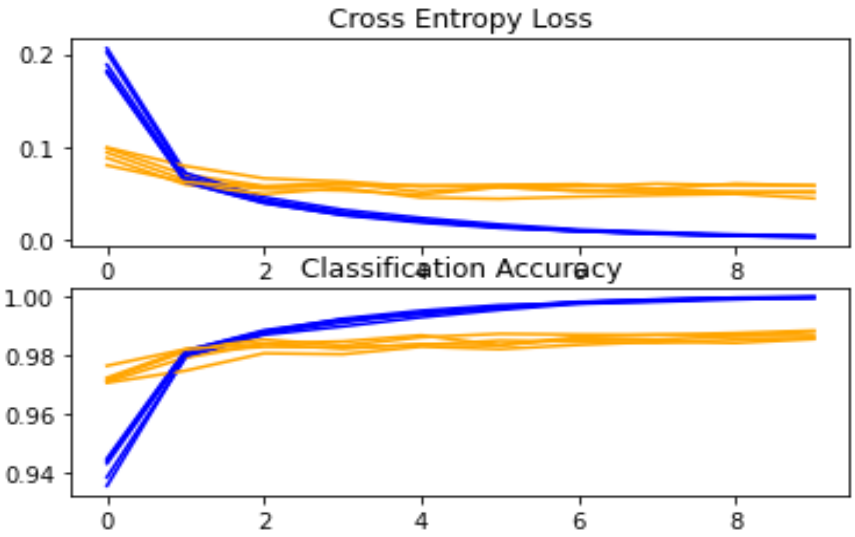


Figure 9 Cross Entropy and Classification accuracy of CNN Model

As shown in Figure 9, first part shows cross entropy loss variation with respect to epochs. Results show that cross entropy loss for training dataset decreases significantly from second epoch and converging after 8 epochs. It also conveys that model is avoiding underfitting or overfitting issues in learning stage. The cross entropy loss for testing dataset also converges after 4 epochs but unable to converge to lower values compared to training loss.

The second part shows accuracy variation with respect to epochs. In line with cross entropy loss for training dataset, accuracy increases significantly from second epoch and converging after 8 epochs. The accuracy of testing dataset does not converge to higher values compared to training accuracy.

5 Introduction to NVIDIA Jetson Nano

This section introduces the NVIDIA Jetson Nano board to be used for our application. To begin with, we will show you the steps to start with Jetson Nano.

Figure 10 NVIDIA Jetson Nano single computer board

The NVIDIA Jetson Nano is a compact, powerful single-board computer that allows many neural networks to operate in parallel for applications including image classification, object identification, segmentation, and speech processing. It includes a full development environment (JetPack SDK) as well as libraries for embedded applications, deep learning, IoT, computer vision, graphics, multimedia, and other topics. The combination of a Jetson Nano and a GeForce-enabled graphics processor (GPU) with the same CUDA cores offers a very powerful application development environment [21]. In addition, the Jetson Nano includes a CPU-GPU hybrid architecture, which allows the operating system to be booted by the CPU and designed to accelerate the CUDA capable GPU's sophisticated machine learning tasks. Artificial intelligence demonstrates that running algorithms use very little electricity. Jetson nano, the Nvidia Jetson ecosystem's medium-sized board, It comes in handy when it comes to computer vision and deep learning[22].

5.1 Getting started with NVIDIA Jetson Nano

1. Hardware components
    - NVIDIA Jetson Nano
    - 64 GB Micro SD Card
    - Wireless Mouse and keyboard
    - HDMI Display and HDMI cable
    - DC Power supply
2. Software components

- SD Memory Card Formatter
- Etcher

3. Steps for initial configuration
    - Download the Jetson Nano Developer Kit SD Card Image to the local PC.
    - Using SD Memory Card Formatter, quick format the 64 GB memory card.
    - Launch Etcher, load downloaded image on the micro SD card.
    - Insert the memory card into Jetson Nano, connect peripherals (mouse, keyboard, HDMI display, power adapter) and power up.

5.2 OpenCV

OpenCV (Open Computer Vision) is a library that implements a number of standard computer vision techniques. Images are huge, two-dimensional arrays of pixels that are saved on computers. Video, which is recorded as a series of pictures, may likewise benefit from computer vision algorithms. OpenCV includes algorithms for tasks such as recognizing faces in images, recognizing preset items and shapes, and detecting movement in videos. OpenCV has a number of methods for identifying objects in images. For the proposed research work, whole of the algorithms were coded using OpenCV using Python programming.

6 Experimental setup

This section briefly explains how the aforementioned approaches were put into reality in our system. The following image is the setup made for implementation:

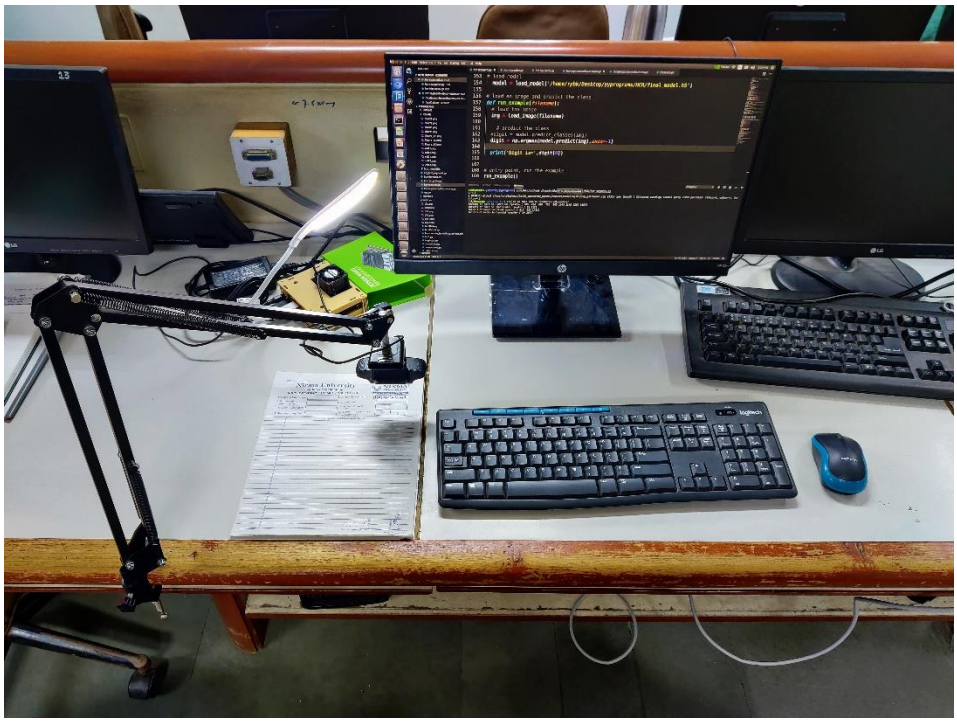


Figure 11 Snapshot of the prototype system for automated marksheet generation

6.1 Segmentation results

The proposed system captures image of student marksheet through webcam.

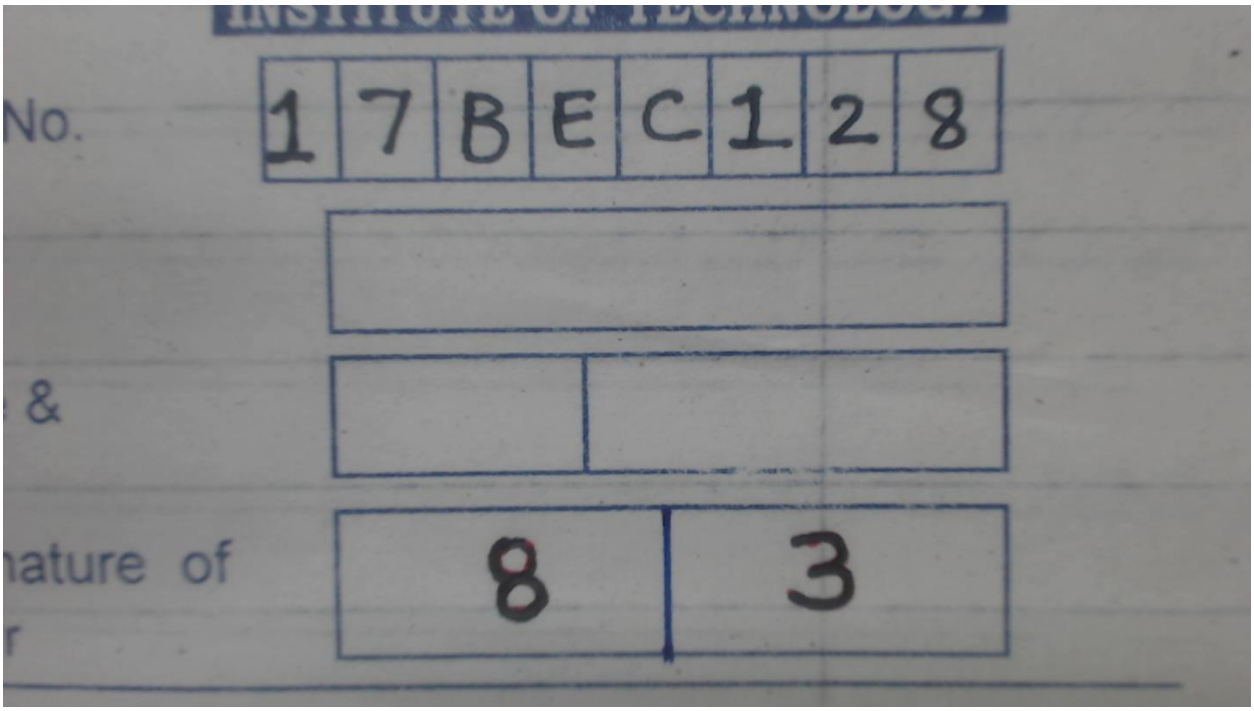


Figure 12 Capture image of student marksheet

Next, image is segmented in two parts: roll number and marks.

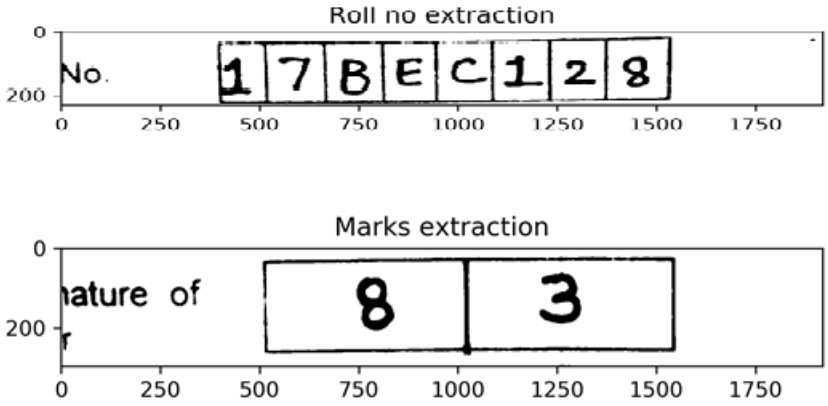
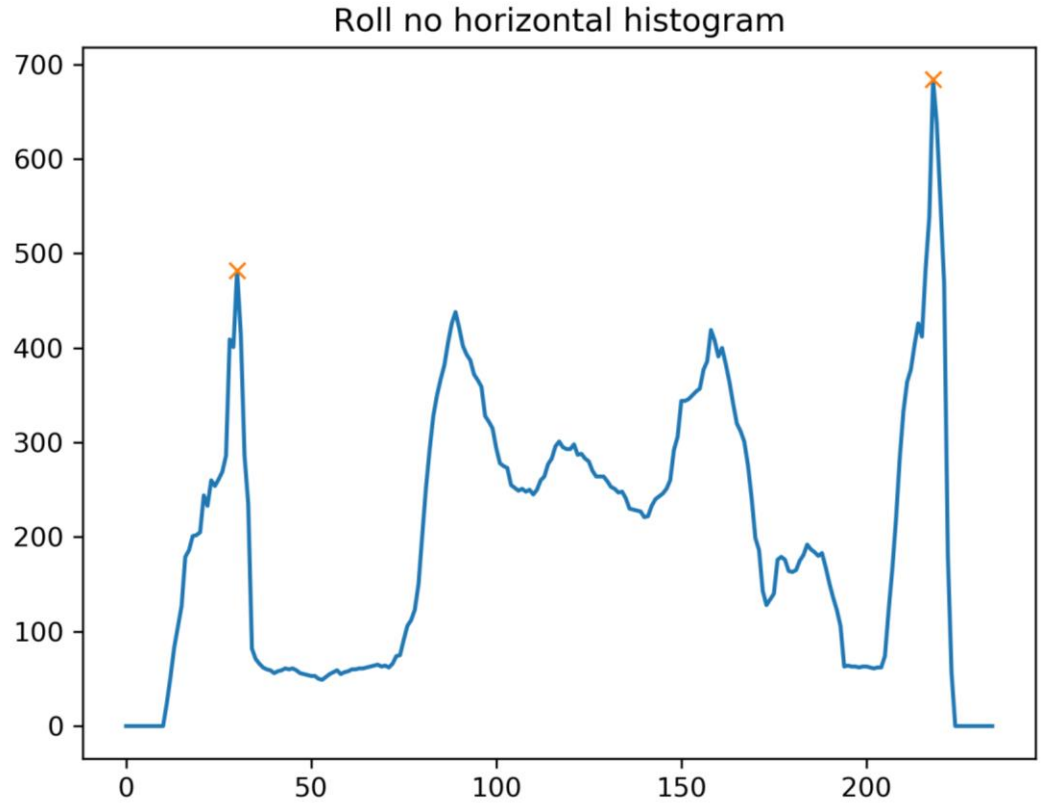
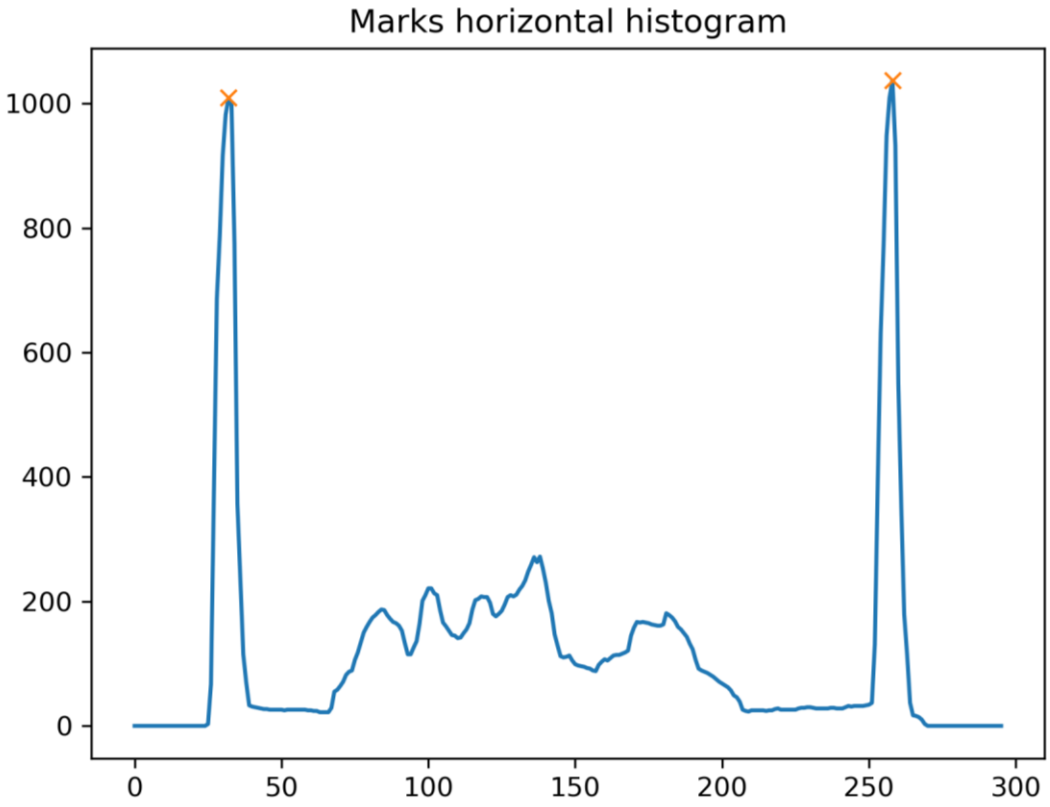


Figure 13 Segmentation of student roll number and marks

From both these marksheets, determine vertical and horizontal histogram to segment individual roll number an, extract individual digits of roll numbers and marks.


Roll no horizontal histogram
700
600
500
400
300
200
100
0
0
50
100
150
200


Marks horizontal histogram
1000
800
600
400
200
0
0
50
100
150
200
250
300

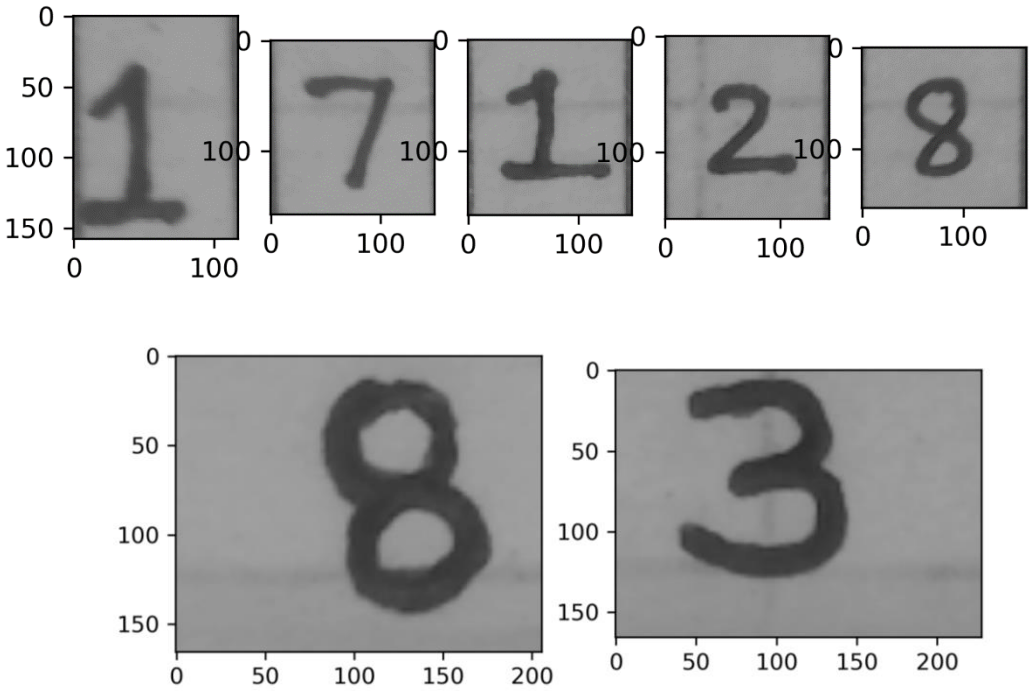


Figure 14 Segmentation results

6.2 Recognition results

The recognition of characters are stored in excel sheet as shown in Figure below:

marksheet.csv — Open with

	A	B	C	D	E
1	Semester	Course Name	Course Code	Roll No.	Marks
2	V	DSP	2EC502	18BEC029	79
3	v	DSP	2EC502	18BEC928	19
4	v	DSP	2EC502	18BEC028	78
5	v	DSP	2EC502	06BEC072	17
6	v	DSP	2EC502	07BEC228	13
7	v	DSP	2EC502	18BEC075	88
8	v	DSP	2EC502	06BEC072	84
9	v	DSP	2EC502	18BEC075	88
10	v	DSP	2EC502	11BEC111	11
11	v	DSP	2EC502	18BEC098	64
12	v	DSP	2EC502	07BEC228	83
13	v	DSP	2EC502	12BEC128	83
14	v	DSP	2EC502	17BEC128	83
15	v	DSP	2EC502	46BEC027	56
16	v	DSP	2EC502	17BEC128	83

Figure 15 Student roll number and marks entry in excel spreadsheet

7 Conclusion and Future aspects

This section summarizes the work of automatic marksheet generation system to prepare a digital record of student marks. In addition, we suggest future direction that leads to improve the proposed framework for scalability and enhancing accuracy.

7.1 Conclusion

This project proposed a prototype system to prepare a record of student roll number along with assigned marks automatically. We used a simple and effective horizontal and vertical projection histogram framework for segmentation of roll number and marks. Results shows the efficient performance of the proposed framework. For recognition purpose, we develop a CNN model and train it with widely used MNIST dataset. The CNN model achieved an accuracy over 98% in validation phase. This CNN model is further utilized for individual character recognition. Towards the end, recognized roll number and marks of the student is recorded in excel spreadsheet automatically. This prototype enables a faculty to prepare a record of student marksheet without causing error while entry.

7.2 Future aspects

The classifier's robustness was a problem, as was the lack of a clear segmentation point on connected digits, and the training time of traditional neural networks was too long to complete statistical analysis of all conceivable combinations of the experiment variables. Although a novel approach for cutting or segmenting digit strings can be offered, there are several limitations to this method that must be addressed. As a result, there is room for future work such as:

- Different categorization models might be utilized at the same time to increase segmentation performance.
- To lower the complexity of the algorithm, it is preferable to reduce the number of hypotheses. This will allow the algorithm to run more quickly.
- Better filters should be employed to eliminate the unneeded segmentation hypotheses in order to save computation time.

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