**A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM**

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* **INTRODUCTION**

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* Machine learning and deep learning plays an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and many more areas.
* This article presents recognizing the handwritten digits (0 to 9) from the famous MNIST dataset, comparing classifiers like KNN, PSVM, NN and convolution neural network on basis of performance, accuracy, time, sensitivity, positive productivity, and specificity with using different parameters with the classifiers.
* To make machines more intelligent, the developers are diving into machine learning and deep learning techniques. A human learns to perform a task by practicing and repeating it again and again so that it memorizes how to perform the tasks. Then the neurons in his brain automatically trigger and they can quickly perform the task they have learned. Deep learning is also very similar to this.It uses different types of neural network architectures for different types of problems.
* For example – object recognition, image and sound classification, object detection, image segmentation, etc.
* The handwritten digit recognition is the ability of computers to recognize human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different flavors. The handwritten digit recognition is the solution.
* Project Overview **:**
* Digit recognition system is the working of a machine to train itself or recognizing the digits from  different sources like emails, bank cheque, papers, images, etc. and in different real-world scenarios for online handwriting recognition on computer tablets or system, recognize number plates of , numeric entries in forms filled up by hand and so on.

**1.2purpose**

Handwritten character recognition is one of the practically important issues in pattern recognition applications. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit strings. To accomplish the recognition task, first, the digits will be segmented into individual digits. Then, a digit recognition module is employed to classify each segmented digit completing the handwritten digit string recognition task. The applications of digit recognition include postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize handwritten digits and which is submitted by users by the way of a scanner, tablet, and other digital devices.

* **LITERATURE SURVEY**

An early notable attempt in the area of character recognition research is by Grims dale in 1959. The origin of a great deal of research work in the early sixties was based on an approach known as analysisby-synthesis method suggested by Eden in 1968. The great importance of Eden's work was that he formally proved that all handwritten characters are formed by a finite number of schematic features, a point that was implicitly included in previous works. This notion was later used in all methods in syntactic (structural) approaches of character recognition.

1. K. Gaurav, Bhatia P. K. , his paper deals with the various pre-processing techniques involved in the character recognition with different kind of images ranges from a simple handwritten form based documents and documents containing colored and complex background and varied intensities.In this, different preprocessing techniques like skew detection and correction, image enhancement techniques of contrast stretching, binarization, noise removal techniques, normalization and segmentation, morphological processing techniques are discussed.

2. Sandhya Arora , used four feature extraction techniques namely, intersection, shadow feature, chain code histogram and straight line fitting features. Shadow features are computed globally for character image while intersection features, chain code histogram features and line fitting features are computed by dividing the character image into different segments. On experimentation with a dataset of 4900 samples the overall recognition rate observed was 92.80% for Devanagari characters.

3. Brakensiek, J. Rottland, A. Kosmala, J. Rigoll, in their paper a system for off-line cursive handwriting recognition is described which is based on Hidden Markov Models (HMM) using discrete and hybrid modelling techniques. Handwriting recognition experiments using a discrete and two different hybrid approaches, which consist of a discrete astructures, are compared. It is found that the recognition rate performance can be improved of a hybrid modelling technique for HMMs, which depends on a neural vector quantizer (hybrid MMI), compared to discrete and hybrid HMMs, based on tired mixture structure (hybrid - TP), which may be caused by a relative small data set and semi-continuous structure

4. R. Bajaj, L. Dey, S. Chaudhari , employed three different kinds of features, namely, the density features, moment features and descriptive component features for classification of Devanagari Numerals. They proposed multi classifier connectionist architecture for increasing the recognition reliability and they obtained 89.6% accuracy for handwritten Devanagari numerals.

5. G. Pirlo and D. Impedovo in his work on , presented a new class of membership functions, which are called Fuzzymembership functions (FMFs), for zoning-based classification. These FMFs can be easily adapted to the specific characteristics of a classification problem in order to maximize classification performance. In this research, a realcoded genetic algorithm is presented to find, in a single optimization procedure, the optimal FMF, together with the optimal zoning described by Voronoi tessellation. The experimental results, which are carried out in the field of handwritten digit and character recognition, indicate that optimal FMF performs better than other membership functions based on abstract level, ranked-level, and measurement-level weighting models, which can be found in the literature.

6. Sushree Sangita Patnaik and Anup Kumar Panda May 2011 , this paper proposes the implementation of particle swarm optimization (PSO) and bacterial foraging optimization (BFO) algorithms which are intended for optimal harmonic compensation by minimizing the undesirable losses occurring inside the APF itself. The efficiency and effectiveness of the implementation of two approaches are compared for two different conditions of supply. The total harmonic distortion (THD) in the source current which is a measure of APF performance is reduced drastically to nearly 1% by employing BFO. The results demonstrate that BFO outperforms the conventional and PSO based approaches by ensuring excellent functionality of APF and quick prevail over harmonics in the source current even under unbalanced supply.

7. M. Hanmandlu, O.V. Ramana Murthy have presented in their study the recognition of handwritten Hindi and English numerals by representing them in the form of exponential membership functions which serve as a fuzzy model. The recognition is carried out by modifying the exponential membership functions fitted to the fuzzy sets. These fuzzy sets are derived from features consisting of normalized distances obtained using the Box approach. The membership function is modified by two structural parameters that are estimated by optimizing the entropy subject to the attainment of membership function to unity. The overall recognition rate is found to be 95% for Hindi numerals and 98.4% for English numerals.

**2.1**          **Existing problem**

    Existing is used to describe something which is now present, available, or in operation, especially when you are contrasting it with something which is planned for the future. Existing Documents means all of the agreements, documents and instruments in relation to the Existing Debt Existing Documents shall mean, with respect to the Property, all of the Contracts and the Leases. Project reports are an important source for managers and stakeholders, to monitor the current progress and measure against the original schedule. It helps to predict the threats and develop proper steps to recover

.

    The report makes it easier to control the cost and budget apart from the budgeted cost. Project objectives are what you plan to achieve by the end of your project. This might include deliverables and assets, or more intangible objectives like increasing productivity or motivation. Your project objectives should be attainable, time-bound, specific goals you can measure at the end of your PROJECT

.

    A  Project scope is a way to set boundaries on your project and define exactly what goals, deadlines, and project deliverables you'll be working towards. By clarifying your project scope, you can ensure you hit your project goals and objectives without delay or overworkn if brief, project management objectives are the successful development of the project's procedures of initiation, planning, execution, regulation and closure as well as the guidance of the project team's operations towards achieving all the agreed upon goals within the set scope, time, quality and budget standards. The goal of this project is to create a save and resume feature for customers on our Gold subscription plan so that they can start their work and complete it at a later date without losing their data. Determine the effect of telling stories on nursery children's reading fluency.

* A project's purpose explains the reason for its existence, the meaning of what is done, the ambition or dream pursued by the project or the direction it takes and maintains. The definition of this is essential at three levels: for the project and for all stakeholders.

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**2.3 Problem Statement Definition :**

   A problem statement is a concise description of the problem or issues a project seeks to address. The problem statement identifies the current state, the desired future state and any gaps between the two. A problem statement is an important communication tool that can help ensure everyone working on a project knows what the problem they need to address is and why the project is important.

**Importance of a problem statement :**

   A problem statement is important to a process improvement project because it helps clearly identify the goals of the project and outline the scope of a project. It also helps guide the activities and decisions of the people who are working on the project. The problem statement can help a business or organization gain support and buy-in for a process improvement project.

**There are four key elements you should include when writing a problem statement :**

 **Ideal situation:**

The first thing your problem statement should describe is what the ideal situation would be if there wasn't a problem you needed to address. This section identifies the goals and scope of the project is. This section should create a clear understanding of what the ideal environment will be once the issue has been resolved.

**2. Reality :**

     The next section of your problem statement should describe what the current reality is for your company or organization. This section will identify what the problem is, state why it is a problem and identify who the problem is impacting. It will also describe when and where the problem was identified.

**Consequences:**

   The next section of your problem statement should identify what the consequences of the problem are. This section describes the effects of the problem by describing how the people affected by the problem are being impacted and quantifying how much the problem is impacting them. Common consequences can include the loss of time, money, resources, competitive advantage, productivity and more.

**Proposal :**

   The proposal section of a problem statement may contain several possible solutions to the problem, but it is important to remember that it does not need to identify a specific solution. The purpose of the proposal section should be to guide the project team on how they can research, investigate and resolve the problem.

**3. IDEATION & PROPOSED SOLUTION**

**3.1 Empathy Map :**

**3.2 Ideation & Brainstorming**

**BRAINSTORM**

**Why**

   Brainstorming is a great way to generate a lot of ideas that you would not be able to generate by just sitting down with a pen and paper. The intention of brainstorming is to leverage the collective thinking of the group, by engaging with each other, listening, and building on other ideas.Conducting a brainstorm also creates a distinct segment of time when you intentionally turn up the generative part of your brain and turn down the evaluative part. Brainstorming is the most frequently practiced form of ideation.

  Here, you’ll learn the best practices from the very best experts from d.school and IDEO as well of the father of the Brainstorming technique, Alex Osborn. The following are some rules, principles and suggestions so you can make brainstorming sessions much more user-oriented, effective, innovative – and fun.

**When**

You can use brainstorming throughout any design or work process, of course, to generate ideas for design solutions, but also any time you are trying to generate ideas, such as planning where to do empathy work, or thinking about product and services related to your project.

**Rules**

**Set a time limit**

d.school emphasises that the facilitator has to be intentional about setting aside a period when your team will be in “brainstorm mode”. In this time frame, it’s the sole goal to come up with as many ideas as possible, and during this period judgements of those ideas are prohibited. Typically, a Brainstorm will take around 15-60 minutes. It can be shorter or longer, depending on the difficulty of the problem and the motivation and experience of the group.

**Best practice tip**

Alex Osborn, the father of the Brainstorming technique, emphasises that brainstorming sessions should always address a specific question or problem statement (also called a Point of View) as sessions addressing multiple questions are inefficient. Begin with a good problem statement or question. Design Thinkers and other ideation specialists have further developed this approach into the art of framing problem statements via methods.

The facilitator should always set a positive, unthreatening tone and tell participants to reserve criticism for a later critical stage in the ideation process. A Brainstorming session is not the time and the place to evaluate ideas, and you should avoid executional details. It’s crucial that participants are feeling confident by being in a safe environment so they have no fear of being judged by others when they put forward wild ideas. You should create equal opportunities for all participants. The best ideas often come from practitioners ,students and people who dare to think differently – and not necessarily only from the highly skilled and experienced managers.

**sap the energy of a session. Many IDEO conference rooms have brainstorming rules stenciled in 6-inch-high letters on the walls; for example, ‘Go for quantity,’ ‘Encourage wild ideas,’ ‘Defer judgment,’ or ‘One conversation at a time.’**

**Best practice tip:**

The facilitator should suspend judgement. This way, participants will feel free to generate unusual ideas. As a facilitator, you will find that it caneven be a great idea to prohibit the word **“no”**. You’ll be surprised to see how effective this tool is and how it helps open up minds and creates a collaborative, curious, and friendly ideation environment. And you’ll find that it’s pretty fun too when team members have to initially say **“yes”**to even the weirdest ideas. Giving out half-thought-out ideas or strange suggestions is normally notsocially accepted.

These new ways of thinking might give you better solutions.

**"It is easier to tone down a wild idea than to think up a new one.”**

“Wild ideas can often give rise to creative leaps. In thinking about ideas that are wacky or out there we tend to think about what we really want without the constraints of technology or materials. We can then take those magical possibilities and perhaps invent new technologies to deliver them.”

**Aim for quantity**

Aim for as many new ideas as possible. The assumption is that the greater the number of ideas you generate, the bigger your chance is of producing a radical and effective solution. Brainstorming celebrates the maxim **“quantity breeds quality”**.

**Build on each others' ideas**

As suggested by the slogan  brainstorming stimulates the building of ideas by a process of association. Embrace the most out-of-the-box notions and build, build, build. Be positive and build on the ideas of others. Brainstorming works well when participants use each other's ideas to trigger their own thinking. Our minds are highly associative. One thought easily triggers another. When we use the thoughts of others, then these will stop us getting trapped by our own thinking structures.

**Best practice tip:**

Try to say and encourage others to say **“and”**instead of **“but”**. It takes practice, but this little trick works surprisingly well.

**Be visual**

**Best practice tip:**

At IDEO, they encourage you to use coloured markers to write on Post-its and put them on the wall—or sketch your idea. Nothing gets an idea across faster than drawing it. It doesn’t matter how terrible of a sketcher you are! It's all about the idea behind your sketch. And d.school has two great ideas for you:

“There are at least two ways to capture the ideas of a brainstorming:

1. Scribe: the scribe legibly and visually captures on the board ideas that team members call out. It is very important to capture every idea, regardless of your own feelings about each idea.

2. All-in: Each person will write down each of his or her ideas as they come, and verbally share it with the group. It is great to do this with post-it notes, so you can write your idea and then stick it on the board.”

**One conversation at a time**

Listen to each other and elaborate on each other’s ideas. Don’t get obsessed with your own ideas. You’re here to ideate together. When all team members have presented their ideas, you can select the best ideas, which you can continue to build and elaborate on in other ideation sessions.

**WHAT   IS IDEATION?**

Ideation essentially refers to the whole creative process of coming up with and communicating new ideas. Ideation is innovative thinking, typically aimed at solving a problem or providing a more efficient means of doing or accomplishing something. It encompasses thinking up new ideas, developing existing ideas, and figuring out means or methods for putting new ideas into practice.

In the business world, ideation is associated with things such as inventing and/or developing new products or services or creating new means or methods of production or delivery of products or services. Amazon’s **“Prime”**two-day delivery service is an example of ideation being used to address the question of how to serve consumers more efficiently.

Ideation is frequently part of what is known as the **“design process,”** which is the process of developing a plan for producing a new product or creating a new operating system. It may also include detailing or mapping out precisely how a new system or process will be implemented.

**HOW  IT WORK IDEATION?**

**Ideation may present itself in any one of a wide variety of ways and are Several different forms that ideation may take, including the following:**

**1.**Derivative Solving Problems – Ideation is often specifically aimed at problem-solving. For example, production managers at a company may be charged with coming up with ideas on how to reduce production costs.

**2.**Derivative Ideation – Derivative ideation refers to building on an existing idea, such as developing complementary products or accessories to sell along with a company’s main product.

**3.**Innovation – An example of innovation ideation is the process of a pharmaceutical company developing new medicines. Such a type of ideation often involves doing extensive research and experimentation as part of the ideation process.

**4.**Development of a **“Revolutionary Idea”**– Ideation sometimes ends up creating a totally new line of thought or set of ideas, such as the development of a new philosophy.

**5**. Serendipitous Ideation – Serendipitous ideation refers to situations where someone just happens to come up with a new idea even though they weren’t consciously trying to do so.

**6**. Combination Ideation – Ideation often includes combining multiple ideas to create a new process or way of doing something.

**IDEATION  AND  BRAINSTROMING**

Ideation is often closely related to the practice of brainstorming, a specific technique that is utilized to generate new ideas. A principal difference between ideation and brainstorming is that ideation is commonly more thought of as being an individual pursuit, while brainstorming is almost always a group activity. Brainstorming is usually conducted by getting a group of people together to come up with either general new ideas or ideas for solving a specific problem or dealing with a specific situation.

Participants in a brainstorming session are encouraged to freely toss out whatever ideas may occur to them. The thinking is that by generating a large number of ideas, the brainstorming group is likely to come up with a suitable solution for whatever issue they are addressing.

The lines between ideation and brainstorming have become a bit more blurred with the development of several brainccccstorming software programs, such as Bright idea and Ideawake. These software programs are designed to encourage employees of companies to generate new ideas for improving the companies’ operations and, ultimately, bottom-line profitability.

The programs often combine the processes of ideation and brainstorming in that individual employees can use them, but companies may simulate brainstorming sessions by having several employees all utilize the software to generate new ideas intended to address a specific purpose.

**History of Brainstorming:**

The term Brainstorming is used and popularized by Alex Faickney Obsorn in 1953 through the book Applied Imagination. In this book Obsorn presented the Brainstorming method and effective rules for brainstorming session. When he was jobless, he worked as press reporter, he also wrote book but  publisher rejected his book because of old ideas. Publisher told him his book was not new, lacking in creative ideas. Later Osborn started his own advertisement company to provide new creative ideas. Osborn organized studies of group discussions to solve problems in 1939. He was frustrated by employees’ inability to develop creative ideas. He began mass group thinking sessions and discovered significant improvement in the ideas produced by employee. Many experiential studies have been conducted regarding group idea generation. Some studies have ignored a few basic issues framed by inventor of the tool.

**Advantages of Brainstorming:**

**1 .**Encourage creativity: brainstorming generate a lot of ideas, It

encourages creativity of organization. It expands members thinking to produce maximum ideas on problem. It can give number of options.Ideas are formed collectively not individually**.**

**2.**Production of large number of ideas: group discussion is organized;facilitator motivates to offer to produce maximum ideas in less time from participant members. It helps to record maximum ideas.

**3.**Involvement of all group members; It is important to produce each participants own idea on particular problem, it dose not criticize or evaluates so it encourages member to produce idea.

**4.**Sense of ownership: Group members are actively participating in brainstorming process. It creates ownership sense to discussion and produce ideas related problem

**5.**Provide input to other tools: brainstorming results are also used in other tools, databases, standardization etc. Generated ideas can be used elsewhere.

**6.**You don't have to be a highly qualified expert or highly paid consultant to use it.

**7. Easy to prepare, implement, understand - it's not a complicated**

**technique**

**8. Save Time and money: Brainstorming is inexpensive. It does not need**

**a lot of materials. (only paper and pens are needed). It save the time.**

**9.**It is fun and exciting.

Problem solving process:

When problem is identified then brainstorming can used to solve or find out solution of raised problem. Following steps are involved in problem.

**Solving Process.**

1.Problem identification

2. Problem definition

3. Problem analysis

4. Identifying causes

5. Find out the root causes

6. Data analysis

7. Solution generation

8. Identifying resistances

9. Plan for solution implementation

10. Implementation

11. Observation

12. Standardization

  **3.3 Proposed Solution**

Project team shall fill the following information in proposed solution template.

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Parameter** | **Description** |
|  | Problem Statement (Problem to be solved) | A Problem statement is a concise description of an issue to be addressed or a condition to be improved upon. it identifies the gap between the current(problem) state and desired (goal) state of a process or product.focusing on the facts, the problem statement should be designed to address the five ws. |
|  | Idea / Solution description | IDEA SOULTIONS is a progressive, state of the art Information Technology company located in Southern Maryland.We have a proven track record of customer satisfaction with our cilents, ranging from residential clients to small businesses to mid-size corporations and government offices and agencies. |
|  | Novelty / Uniqueness | Novelty is a synonym of uniqueness. As nouns the different between novelty and uniqueness is that novelty is the state of being new or novel; newness while uniqueness is the state or quality of being unique or one-of-a-kind. |
|  | Social Impact / Customer Satisfaction | social media use will indirectly impact customer satisfaction, ...assess the cost of this incresed satisfaction, benefit and responsiveness rather than directly from social media. |
|  | Business Model (Revenue Model) | A revenue model is a framework for generating financial income. it idefinites which revenue source to pursuue, what a value to offer, how to price the value, and who pays to the value. it is a key component of a company 's business model. |
|  | Scalability of the Solution | scalability is an aspect or rather a functional quality of a system, software or solution. A system that can accommodate expansion without hampering the existing workflow and ensure an increase in the output or efficiency of the process,is a scalable system. |

**3.4 Problem Solution fit**

**4. REQUIREMENT ANALYSIS**

    4.1 Functional requirement

    4.2 Non-Functional requirements

**5. PROJECT DESIGN**

    5.1 Data Flow Diagrams

    5.2 Solution & Technical Architecture

    5.3 User Stories

**6. PROJECT PLANNING & SCHEDULING**

    6.1 Sprint Planning & Estimation Project Planning Phase

7.CODING AND SOLUTIONING

7.1 FEATURE 1

7.2 FEATRUE 2

7.3 DATABASE SCHEMA (IF APPLICABE

Import the libraries and load the dataset: First, we are going to import all the modules that we are going to need for training our model. The Keras library already contains some datasets and MNIST is one of them. So we can easily import the dataset and start working with it.

The mnist.load\_data() method returns us the training data, its labels and also the testing data and its labels. import keras from keras.datasets import mnist from keras.models import Sequential from keras.layers import Dense, Dropout, Flatten from keras.layers import Conv2D, MaxPooling2D from keras import backend as K (x\_train, y\_train), (x\_test, y\_test) = mnist.load\_data() print(x\_train.shape, y\_train.shape) 50 Figure 17 Output Training and Test Data Shape .

Preprocess the data:

The image data cannot be fed directly into the model so we need to perform some operations and process the data to make it ready for our neural network. The dimension of the training data is (60000,28,28). The CNN model will require one more dimension so we reshape the matrix to shape (60000,28,28,1).

x\_train = x\_train.reshape(x\_train.shape[0], 28, 28, 1) x\_test = x\_test.reshape(x\_test.shape[0], 28, 28, 1) input\_shape = (28, 28, 1) #convert class vectors to binary class matrices y\_train = keras.utils.to\_categorical(y\_train, num\_classes) y\_test = keras.utils.to\_categorical(y\_test, num\_classes) x\_train = x\_train.astype('float32') x\_test = x\_test.astype('float32') x\_train /= 255 x\_test /= 255 print('x\_train shape:', x\_train.shape) print(x\_train.shape[0], 'train samples') print(x\_test.shape[0], 'test samples')

**8. TESTING**

    8.1 Test Cases

    8.2 User Acceptance Testing

**9. RESULTS**

    9.1 Performance Metrics

**10. ADVANTAGES & DISADVANTAGES**

**11**. **CONCLUSION**

* Our project HANDWRITTEN DIGIT RECOGNITION deals with identifying the digits. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit strings.
* In this project, different machine learning methods, which are SVM (Support Vector Machine), ANN (Artificial Neural Networks), and CNN (Convolutional Neural Networks) architectures are used to achieve high performance on the digit string recognition problem.

**Future Work :**

* The proposed system takes 28x28 pixel sized images as input. The same system with further modifications and improvements in the dataset and the model can be used to build Handwritten Character Recognition System which recognizes human handwritten characters and predicts the output

**12. FUTURE SCOPE**

**13**. **APPENDIX**

* Python:
* Python is an interpreted, high-level, general purpose programming language created by Guido Van Rossum and first released in 1991, Python's design philosophy emphasizes code Readability with its notable use of significant White space. Its language constructs and object oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage collected. It supports multiple programming paradigms, including procedural, objectoriented, and functional programming.
* Keras :
* Keras is a powerful and easy-to-use free open source Python library for developing and evaluating deep larning models. It wraps the efficient numerical computation libraries Theano and TensorFlow and allows you to define and train neural network models in just a few lines of code. It uses libraries such as Python, C#, C++ or standalone machine learning toolkits. Theano and TensorFlow are very powerful libraries but difficult to understand for creating neural networks. Keras is based on minimal structure that provides a clean and easy way to create deep learning models based on TensorFlow or Theano. Keras is designed to quickly define deep learning models. Well, Keras is an optimal choice for deep learning applications.

    Source Code

    GitHub & Project Demo Link

<https://drive.google.com/file/d/1k_33GFmPzLozFW74SC04D1nZPaNkvCsJ/view?usp=drivesdk>

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