Improved RNN-based System for Deciphering Doctors' Handwritten Prescriptions

A. Maiti, A. Podder, C. Dutta, and D. Saha

***Abstract*--This research introduces a novel approach towards deciphering and understanding medical prescriptions by employing Handwritten Character Recognition (HCR) and Recurrent Neural Networks (RNN). Our method offers an innovative solution to the longstanding problem of interpreting physicians' handwritten notes, shorthand, symbols, and abbreviations in prescriptions, thereby minimizing medication errors due to misinterpretation. The study presents a two-step process that initially uses image processing techniques for enhancing the quality of prescription images, and subsequently applies an RNN-based model to recognize and interpret both handwritten and printed text. A potential application strategy involves the development and release of an open-source platform with an initial version of the model, which is further fine-tuned using real-world user data. The upgraded licensed version could include value-added features such as medicine availability checks, personalized dosage recommendations, and incentives for medicine purchase. The proposed system targets a wide range of users, primarily patients and pharmacists, with the possibility of incorporating personalized medicine suggestions based on customer medical histories and local medicine store inventory information.**

***Index Terms*--Doctor's Prescription; Image Processing; Recurrent neural network (RNN).**

I. Introduction

Each person can express their thoughts on paper in a distinctive way thanks to the skill of handwriting. It could vary considerably from person to person. A doctor's prescription is a medical document that he or she writes to give the patient the medication they need in accordance with the illness or injury they have been dealing with. Prescriptions serve as a record of the drugs that a patient has been given or that are suggested. Due to their busy schedules, doctors often prioritize quick appointment scheduling and accurate diagnosis over legible prescriptions. As a result, their handwriting tends to be poor and difficult to read. As a result, making it is challenging to read prescriptions and identify the medications and potential dosages. According to a recent study by JohnsHopkins, more than 250,000 people in the United States die every year because of medical mistakes, making it the third leading cause of death after heart disease and cancer.

Other studies claim the number is as high as 440,000. The reason for the discrepancy is that physicians, funeral directors, coroners, and medical examiners rarely note on death certificates the human errors and system failures involved. The process of prescription recognition using an RNN typically involves several steps. First, the prescription image is preprocessed to remove noise and enhance the contrast of the handwriting. Then, the RNN is applied to the preprocessed image, segmenting the prescription into individual characters or words. Finally, the recognized characters or words are compared to a database of known drugs to identify the correct medication. The name of the medication, its dosage, and its recommended length of use are all included in a prescription. Standard medical terms and abbreviations are used when a doctor writes a prescription. It's quite difficult to read and comprehend for someone without any prior medical expertise or training. As a result, patients buy prescription drugs blindly without considering if the adverse effects will be acceptable to them or uncomfortable and harmful. Nowadays many doctors write digital prescriptions. Having trouble reading doctors' handwritten prescriptions is a barrier to receiving high-quality medical care. These prescriptions can be difficult to understand and frequently have detrimental medical effects like erroneous medication selection, dose errors, and even fatalities. Because of the doctor's illegible handwriting, the pharmacist accidentally gave the patient, a 42-year-old American, 20 mg Plendil instead of 20 mg Isordil, twice the safe daily dose (for the wrong medication). The physician, a cardiologist, testified in court and was ordered to make restitution to the victim's family.

II. Previous Study

The following table depicts a few related papers, their methods, and their accuracies.

Previous study	AI Methods	Accuracy
Achkar et al. (Achkar,2019)	CRNN	95%

A. Maiti, MCA, Assistant Professor, Guru Nanak Institute of Technology, Kolkata, (e-mail: ananjan.maiti@gmail.com).

A. Podder, MCA, Guru Nanak Institute of Technology, Kolkata (e-mail: podderarghya@gmail.com).

C. Dutta, MCA, Assistant Professor, Guru Nanak Institute of Technology, Kolkata (e-mail: chiranjib.dutta@gnit.ac.in).

D. Saha, MCA, Assistant Professor, Guru Nanak Institute of Technology, Kolkata (e-mail: dola.saha@gnit.ac.in).

Hassan et al. (Hassan,2021)	CNN	70%
Fajardo et al. (Fajardo,2019)	CRNN	72%
Carchiolo et al. (Carchiolo,2017)	FCN	93-95%
Tabassum et al.(Tabassum,2019)	Bidirectional LSTM andSRP	89.5%
Dhande et al. (Dhande,2022)	SVM	85%

Table 1. Different methods and results obtained from the previous study

By using Recurrent neural network (RNN) techniques, we can automate the recognition and extraction of relevant prescription information, such as the name and dosage of medications, patient information, and treatment instructions. This can save time and improve the accuracy of prescription processing, reducing the risk of errors that can occur with manual data entry. A Recurrent neural network (RNN) model for prescription recognition can be trained on a large dataset of prescription images and documents, enabling it to recognize and extract information from a wide range of prescriptions, including those with different formats, languages, and handwriting styles.

III. METHODOLOGY

This project aims to create a software system that can quickly recognize medical prescription pictures or scan them for later conversion to digital text using recurrent neural network (RNN) and artificial neural network methods for image recognition. Word segmentation is used in image processing to analyse the OCR data. The system provides customized output that is easy to understand for most users, even if they lack prior knowledge. This practical project is particularly useful for people who take daily medications as directed by their doctors and simplifies tasks for users and inexperienced pharmacists, enabling them to complete their duties more efficiently and accurately. Recurrent Neural Networks (RNNs) have shown significant promise in the field of handwriting recognition due to their ability to capture the temporal dependencies present in sequential data. RNNs are a type of neural network that can process sequential data by maintaining a hidden state that is updated at each time step. This hidden state allows RNNs to capture the context and dependencies between each element in a sequence. Therefore, RNNs are well-suited for tasks such as handwriting recognition, where the spatial and temporal dependencies between the strokes of each character must be captured.

Several studies have explored the use of RNNs for handwriting recognition in the medical field. For example, researchers have developed RNN-based models to recognize the handwriting of medical professionals on patient charts and electronic health records. These models can accurately recognize medical jargon and abbreviations, which can significantly reduce the time required for medical documentation. Furthermore, RNN-based models can also be used to analyse the patterns in medical professionals' handwriting, which can provide insights into their thought processes and decision-making.

In conclusion, the use of RNNs for handwriting recognition in the medical field has shown significant promise. RNN-based models can accurately recognize medical jargon and abbreviations, capture the temporal dependencies present in sequential data, and provide insights into medical professionals' thought processes. Therefore, further research in this area has the potential to improve the accuracy and efficiency of medical documentation and enhance the quality of patient care.

1. *Building the Dataset*

To train and test the Recurrent neural network (RNN) model, data is an essential part of this system. The data will therefore be generated from scratch for samples for which there is no previous data. This can be accomplished by physically collecting the data and scanning the actual text. The recognition model's dependability will increase because we can maintain the highest level of accuracy by doing this.

2. *Preprocessing* After gathering the data, it will be ordered and processed before being used to train the model. The model can produce inaccurate results if trained on noisy data. Therefore, one must be careful in choosing the correct dataset.

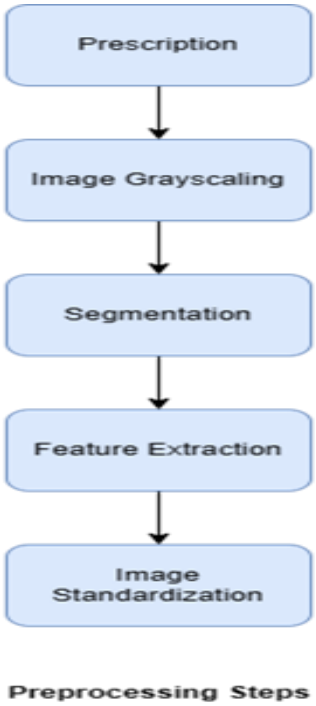


Fig. 1. Process of pre-processing images

3. *Training the Model*

We must first process the prescription text input before using structured data to train the RECURRENT NEURAL NETWORK model. Also, we must avoid overtraining the model to obtain the best recognition system, as doing so will

make the model only appropriate for that specific dataset. To get around this, we will run the model for 50 epochs, which is the recommended amount for training the model to detect the information provided.

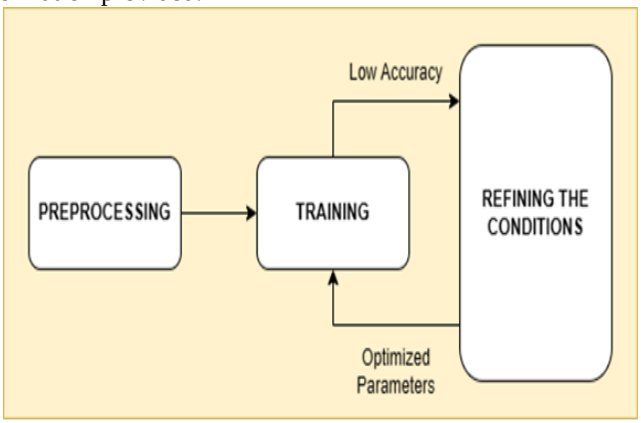


Fig. 2.Steps of model training

4. Prediction & Optimizing

To avoid errors, we'll check our predicted medication in the medical database. Then, we'll use market basket analysis and fuzzy matching to optimize our model post-recognition. Fuzzy search is a database searching technique that enables us to locate search terms by disregarding typos or other inaccuracies in our search term(s). The available medicine database is used for this. Market basket analysis uses prior user behavior to forecast the products that the user could be interested in. Hence, the time needed for name analysis might be cut down since the drug names could be acquired more quickly.

5. Readable Prescription

This application presents clear text and a brief description of recognized medications, making it easy for any user to upload an image and get results. Minimizing the CTC loss function ensures optimal word prediction. The predicted text is amended using a medical data set for a concise overview of recommended medication. To test the model in real-world scenarios, we evaluated it in a nearby drugstore, successfully differentiating between different types of handwritten notes from doctors. The program provides efficient recognition and distribution of memos and prescriptions, benefiting both patients and clients. This self-contained, easy-to-use software employs medical data and advanced methods such as market basket analysis and fuzzy matching to optimize recognition accuracy and enhance the overall user experience.

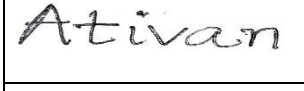
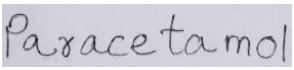
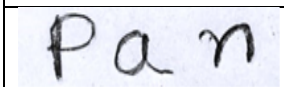
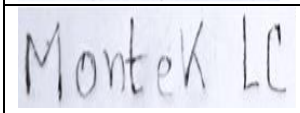
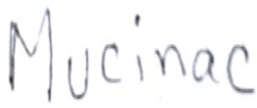
IV. Results and Analysis

To ensure the accuracy of our model and achieve the best results, we trained the model using 50 epochs, which allowed it to effectively recognize words without overfitting to the training data. We allocated 90% of the data for model training and 10% for testing and validation. To maximize word prediction, we minimized the CTC loss function. A medical dataset was used to refine predicted text from images for clear medication summaries. The program provides efficient recognition and distribution of prescriptions. To assess the model's real-world performance, we tested it in a local pharmacy to determine its ability to differentiate various types of doctor's handwritten notes. Impressively, our test case revealed no significant advantages or errors, demonstrating the model's efficiency in recognizing prescriptions and providing them to customers.

The National Academy of Science estimates that at least 1.5 million people are affected by prescription errors annually, often leading to severe health consequences. To address this issue, we utilized a Recurrent Neural Network (RNN) approach in the Medicine Box and smartphone application, which can recognize handwritten medicine names and convert them into readable digital text. This prescription recognition application simplifies the understanding of doctor's handwritten notes, enabling pharmacists to provide the correct medication to customers with ease. As a result, we can prevent incorrect medicine consumption, wrong dosage suggestions, and potentially save lives.

The Doctor's Prescription Recognition application has significant potential for wider adoption. By organizing campaigns and workshops with pharmaceutical companies, we can demonstrate the efficiency and accuracy of the application and address the needs of a broader audience.

A sample picture of how prescription recognition works in an ideal scenario.

Medicine name	Recognized text and probability
	"Ativan" 0.191809^561958313
	"Parsacetanol" 0.13680100660979006
	"Pan" 0.35531681776046753
	"Montek" 0.010420502163469791
	"Mucinac" 0.37264949083328247

V. Discussion

In this paper, we have described mostly what is Doctor's prescription recognition, why it is needed, and how we are achieving this recognition application using Recurrent neural network (RNN). The technique here is to capture the input data text, provide the data feed into the model defined, train the model with more concurrent data, decrypt the data feed

from the model output and send this data as an output with free text. The more accuracy of training data increases the performance of the application. By training with large data sets, application performance can be improved. As a more futuristic solution, we can build this application as an open-source platform at the start and publish a trial version to use by all the stakeholders or customers. Once we come across more traffic with this app, the model inside it will be trained and will perform with high accuracy by using customer data. The more accuracy of training data increases the performance of the application. By training with large data sets, application performance can be improved. As a more futuristic solution, we can build this application as an open-source platform at the start and publish a trial version to use by all the stakeholders or customers. Once we come across more traffic with this app, the model inside it will be trained and will perform with high accuracy by using customer data

VI. Conclusion

This study presents an in-depth exploration of doctor's prescription recognition, illuminating the necessity for such a system and elaborating on the utilization of a Recurrent Neural Network (RNN) to achieve this goal. The core process encompasses capturing and feeding input text into a specified model, training the model using abundant data, decoding the model output, and subsequently delivering this data as interpretable text. Improvements in training data accuracy directly enhances the application's performance, with further performance gains achievable through extensive data set training. Aiming for a progressive approach, the envisaged application could initially be launched as an open-source platform, with a trial version available for all stakeholders or customers. High-traffic engagement with the application will allow the embedded model to learn from a vast pool of customer data, consequently enhancing its accuracy. Once the model's learning reaches a set threshold, e.g., 98% accuracy, a subsequent licensed version of the platform could be introduced. This version would feature additional capabilities, such as checking the availability of prescribed medication in specific stores, suggesting dosages, and providing purchase incentives. The target user base primarily includes patients and pharmacists. The model's functionality could be further enriched by incorporating features that leverage customers' medical histories, providing details on previously consumed medicines and corresponding ailments. Consequently, in the case of recurring diseases, the application could propose previously used medications and even provide information about current store availability, promoting a highly personalized and convenient user experience.

VII. Acknowledgment

This study acknowledges and deeply appreciates the significant contributions of various individuals who have been instrumental in its completion. Profound gratitude is extended to Prof. (Dr.) Shantanu Sen, Principal, and Chiranjib Dutta, the Head of the Department of Computer Application, both at Guru Nanak Institute of Technology. Special thanks are given to project supervisors, Dr. Ananjan Maiti, and Mrs. DolaSaha, whose guidance and constructive feedback have been invaluable throughout the research process. The research team, including ArghyaPodder, has shown commendable dedication and support, bringing unique insights to the table. T

VIII. References

[1] [1] R. Achkar, K. Ghayad, R. Haidar, S. Saleh, and R. Al Hajj. (2019, August). Medical handwritten prescription recognition using crnn. Presented at the 2019 International Conference on Computer, Information and Telecommunication Systems (CITS). [Online]. Available: IEEE Xplore (Include URL if available)

[2] L. J. Fajardo, N. J. Sorillo, J. Garlit, C. D. Tomines, M. B. Abisado, J. M. R. Imperial, et al. (2019, November). Doctor's cursive handwriting recognition system using deep learning. Presented at the 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM). [Online]. Available: IEEE Xplore (Include URL if available)

[3] T. Jain, R. Sharma, and R. Malhotra. (2021, April). Handwriting recognition for medical prescriptions using a CNN-Bi-LSTM model. Presented at the 2021 6th International Conference for Convergence in Technology (I2CT). [Online]. Available: IEEE Xplore (Include URL if available)

[4] Y. Yang, P. A. Fasching, and V. Tresp. (2017, August). Predictive modeling of therapy decisions in metastatic breast cancer with recurrent neural network encoder and multinomial hierarchical regression decoder. Presented at the 2017 IEEE International Conference on Healthcare Informatics (ICHI). [Online]. Available: IEEE Xplore (Include URL if available)

[5] R. Achkar, K. Ghayad, R. Haidar, S. Saleh, and R. Al Hajj. (2019, August). Medical handwritten prescription recognition using crnn. Presented at the 2019 International Conference on Computer, Information and Telecommunication Systems (CITS). [Online]. Available: IEEE Xplore (Include URL if available)

[6] S. Padmanabhan, and N. Divya. (2022). Doctors Handwritten Prescription Recognition System In Multi Language Using Deep Learning. [Online]. Available: arXiv preprint arXiv:2210.11666

[7] P. H. Ng, P. Q. Chen, Z. P. Sin, S. H. Lai, and A. S. Cheng. (2023). Smart Work Injury Management (SWIM) system: a Recurrent neural network (RNN) approach for the prediction of sick leave and rehabilitation plan. Bioengineering, 10(2), 172. [Online]. Available: URL (Include if available)

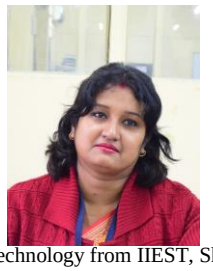
IX. Biographies

Arghya Podder stands as a driven individual with aspirations to carve a significant path in the dynamic landscape of the technology sector. Graduating with honors, he holds a Bachelor of Science degree from the reputed West Bengal State University. His academic prowess didn't stop there; he further advanced his knowledge by securing a Master of Computer Applications (MCA) degree in 2023 from the renowned Guru Nanak Institute of Technology.

Dr. Ananjan Maiti is a passionate young researcher who has a deep understanding of the subject of artificial intelligence based on disease detection. He is a passionate research content writer who always looks for new ways to express new ideas in reputed journals. He holds a Bachelor of Technology degree from JIS College of Engineering, with a specialization in Information Technology (2011).

He earned M.Tech from IIT Kharagpur, a prestigious institute with a specialization in Information and Communication Technology (2015). His scholastic odyssey did not end with the Master's degree; he encouraged His Excellency to pursue a doctorate degree in Computer Science and Engineering from the University of Engineering & Management, Kolkata (2021). He has a total of 8 years of teaching experience and 2 years of industrial experience.

He has worked with the IEM Group, Techno Group, and JIS Group, all of which are reputable academic institutions in Kolkata. He is currently employed as an Assistant Professor in the Department of Computer Science and Engineering at Guru Nanak Institute of Technology (JIS Group). He has already published ten international papers in the previous three years, and his research interests include medical image processing, machine learning, deep learning, and the Internet of Things.



Prof. Dola Saha is a skilled academic with expertise in mathematics and computer science.

Her academic journey started at the Raja Peary Mohan College, University of Calcutta, where she earned a Mathematics Honours degree in 2004. She then achieved a postgraduate degree in Computer Application from the RCC Institute of Information Technology, MAKAUT, in 2008, followed by an M.Tech in Information Technology from IIEST, Shibpur, in 2016.

MrsSaha's areas of speciality include Cryptography, Steganography, Data Mining, and Machine Learning, highlighting her broad and diverse skill set in information technology. As an active member of The Institution of Engineers (IE) and the Computer Society of India (CSI), she remains committed to her field, fostering professional relationships and making ongoing contributions.

Mr. Chiranjib Dutta is an accomplished academic and researcher with an impressive background in Mathematics and Computer Science. He embarked on his scholarly journey at the University of Calcutta, where he graduated with Honours in Mathematics. Broadening his knowledge base further, he pursued an MCA from Bangalore University, followed by an ME in Computer Science and Engineering from the West Bengal University of Technology.

Currently, Mr. Dutta is serving as the Head of the Department of Computer Applications at Guru Nanak Institute of Technology, located in Kolkata. He has dedicated his professional life to nurturing the next generation of tech-savvy individuals, imparting both knowledge and wisdom.

His primary research interest lies in the intriguing realms of Artificial Intelligence and Soft-computing. His insatiable curiosity and rigorous research methods have led to numerous publications in respected, peer-reviewed journals. These contributions not only highlight his in-depth understanding of the subject but also underline his unwavering commitment to advancing the field of computer science and its related application.