Lecture Notes in Networks and Systems 949

Tomonobu Senjyu
Chakchai So–In
Amit Joshi *Editors*

Smart Trends in Computing and Communications

Proceedings of SmartCom 2024, Volume 5

Springer

Lecture Notes in Networks and Systems

Volume 949

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Tomonobu Senjyu · Chakchai So–In · Amit Joshi
Editors

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Editors
Tomonobu Senjyu
Faculty of Engineering
University of the Ryukyus
Nishihara, Okinawa, Japan

Chakchai So–In
College of Computing
Khon Kaen University
Khon Kaen, Thailand

Amit Joshi
Global Knowledge Research Foundation
Ahmedabad, Gujarat, India

ISSN 2367-3370 ISSN 2367-3389 (electronic)
Lecture Notes in Networks and Systems
ISBN 978-981-97-1312-7 ISBN 978-981-97-1313-4 (eBook)
https://doi.org/10.1007/978-981-97-1313-4

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The Eighth Edition of the SmartCom 2024—Smart Trends in Computing and Communications will be held during 12 and 13 January 2024, physically at hotel: Crowne Plaza, Pune City Centre, Pune, India, and digitally on Zoom which is organized by Global Knowledge Research Foundation and managed by G R Scholastic LLP. The associated partners were Springer Nature and Springer, and National Chamber Partner Knowledge Chamber of Commerce and Industry. The conference will provide a useful and wide platform both for display of the latest research and for exchange of research results and thoughts. The participants of the conference will be from almost every part of the world, with background of either academia or industry, allowing a real multinational multicultural exchange of experiences and ideas.

A great pool of more than 1200 papers were received for this conference from across 18 countries among which around 202 papers were accepted with this springer series and were presented through digital platform during the two days. Due to overwhelming response, we had to drop many papers in hierarchy of the quality. Total 33 technical sessions will be organized in parallel in 2 days along with few keynotes and panel discussions. The conference will be involved in deep discussion and issues which will be intended to solve at global levels. New technologies will be proposed, experiences will be shared, and future solutions for enhancement in systems and security will also be discussed. The final papers will be published in proceedings by Springer LNNS Series.

Over the years, this conference has been organized and conceptualized with collective efforts of a large number of individuals. I would like to thank each of committee members and the reviewers for their excellent work in reviewing the papers. Grateful acknowledgements are extended to the team of Global Knowledge Research Foundation for their valuable efforts and support.

Nishihara, Japan — Tomonobu Senjyu
Khon Kaen, Thailand — Chakchai So–In
Ahmedabad, India — Amit Joshi

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Editors and Contributors

About the Editors

Prof. Tomonobu Senjyu received his B.S. and M.S. degrees in Electrical Engineering from the University of the Ryukyus, Nishihara, Japan, in 1986 and 1988, respectively, and his Ph.D. in Electrical Engineering from Nagoya University, Japan, in 1994. He is currently Full Professor at the Department of Electrical and Electronics Engineering, University of the Ryukyus. His research interests include renewable energy, power system optimization and operation, power electronics, and advanced control of electrical machines.

Prof. Chakchai So–In has been with the Department of Computer Science at Khon Kaen University since 2010. He received his B.E. and M.E. degrees from Kasetsart University (KU), Bangkok, Thailand, in 1999 and 2001, respectively. He also completed M.S. and Ph.D. degrees in Computer Engineering at the Department of Computer Science and Engineering, Washington University, in St. Louis (WUSTL), MO, USA, in 2006 and 2010. He has authored more than 100 publications in prominent journals and proceedings, together with 10 books. His research interests include mobile computing/sensor networks, Internet of things, computer/wireless/distributed networks, cybersecurity, intelligent systems and the future Internet. He is Senior Member of the IEEE and ACM.

Dr. Amit Joshi is currently Director of Global Knowledge Research Foundation, also Entrepreneur Researcher who has completed his Masters' and research in the areas of cloud computing and cryptography in medical imaging. He has an experience of around 10 years in academic and industry in prestigious organizations. He is Active Member of ACM, IEEE, CSI, AMIE, IACSIT-Singapore, IDES, ACEEE, NPA and many other professional societies. Currently, he is International Chair of InterYIT at International Federation of Information Processing (IFIP, Austria). He has presented and published more than 50 papers in national and international journals/conferences of IEEE and ACM. He has also edited more than 40 books which are published by Springer, ACM and other reputed publishers. He has also organized more than 50 national and international conferences and programmes in association with ACM, Springer, IEEE to name a few across different countries including India, UK, Europe, USA, Canada, Thailand, Egypt and many more.

Contributors

Shinu Abhi REVA Academy for Corporate Excellence (RACE), REVA University, Bangalore, India

T. Varun Adhavan Department of CSE, Rajalakshmi Engineering College, Chennai, India

Rashmi Agarwal REVA Academy for Corporate Excellence (RACE), REVA University, Bangalore, India

Jitendra Agrawal School of Information Technology, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India

Sonu Airen School of Information Technology, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India

V. Anand REVA Academy for Corporate Excellence (RACE), REVA University, Bangalore, India

Abir Hossain Apon Department of Computer Science and Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India

J. Sangeetha Archana Department of CSE, Rajalakshmi Engineering College, Chennai, India

Harshal Arolkar GLS University, Ahmedabad, India

M. Babu Department of Information Technology, Rajalakshmi Engineering College, Chennai, India

Shivam Baghele Shri Ramdeobaba College of Engineering and Management, Nagpur, India

Poonam Bansal Indira Gandhi Delhi Technical University for Women, Delhi, India

M. Bhanurangarao Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India

Vishnu Kumar Bharadwaj Ramiah Institute of Technology, Bangalore-54, India

Mukul Bhatnagar Chandigarh University, Mohali, India

Vrushali Bongirwar Shri Ramdeobaba College of Engineering and Management, Nagpur, India

Prashant P. Bora Bora Multicorp, Pune, India

Robin Carlsson University of Turku, Turku, Finland

Dipanwita Chakrabarty Haldia Institute of Technology, Haldia, West Bengal, India

Bhakti Chavan Department of Information Technology, MKSSS's Cummins College of Engineering for Women, Pune, Maharashtra, India

J. Chenni Kumaran Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India

Sahil Chharra Shri Ramdeobaba College of Engineering and Management, Nagpur, India

Ashok Chikaraddi School of Computer Science and Engineering, KLE Technological University, Hubballi, Karnataka, India

C. H. Sneha Chinmayee Ramiah Institute of Technology, Bangalore-54, India

Rupali Choudhary Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

Md. Tanvir Chowdhury Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

V. Dattatreya CVR College of Engineering, Hyderabad, India

Saswati Debnath Alliance University, Bangalore, Karnataka, India

Shubhangi Deokar Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

Amita Dev Indira Gandhi Delhi Technical University for Women, Delhi, India

Soumya Kanti Dhara Haldia Institute of Technology, Haldia, West Bengal, India

M. Vishnu Dharshan Department of CSE, Rajalakshmi Engineering College, Chennai, India

Amol Dhumane Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

Shubham Durgude Bora Multicorp, Pune, India

D. Evangeline Ramiah Institute of Technology, Bangalore-54, India

Noor Fathima REVA Academy for Corporate Excellence (RACE), REVA University, Bangalore, India

Akhilesh Gadagkar School of Computer Science and Engineering, KLE Technological University, Hubballi, Karnataka, India

Sandeep Gaikwad Symbiosis Institute of Computer Studies and Research (SICSR), Symbiosis International (Deemed University), Pune, India

Sanjay Gaur Department of Computer Science & Engineering, JECRC, Jaipur, India

Dinnepati Reddy Sai Geethesh Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Arunangshu Giri Haldia Institute of Technology, Haldia, West Bengal, India

Shilpa Gite Artificial Intelligence and Machine Learning Department, Symbiosis Institute of Technology, Symbiosis International (Deemed) University, Pune, India; Symbiosis Centre of Applied AI (SCAAI), Symbiosis International (Deemed) University, Pune, India

Rajat Goel University School of Business, Chandigarh University, Mohali, Punjab, India

Sanjay Gour Department of Computer Science and Engineering, JECRC, Jaipur, India

Monali Gulhane Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune, India

Timi Heino University of Turku, Turku, Finland

Sagar Janokar Vishwakarma Institute of Technology, Pune, India

Ashwin Thejus Justin Veolia Water Technologies Via Dexterra Group, Oakville, ON, Canada

Anil Kalotra University School of Business, Chandigarh University, Mohali, Punjab, India

Priyadarshini Kalwad School of Computer Science and Engineering, KLE Technological University, Hubballi, Karnataka, India

Suvarna Kanakaraddi School of Computer Science and Engineering, KLE Technological University, Hubballi, Karnataka, India

Khush Kanjia Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

Krishna Kant Charotar University of Science and Technology, Changa, India

Vikram Kashyap Shri Ramdeobaba College of Engineering and Management, Nagpur, India

Shreya Kathiriand Smt. Kundaben Dinsha Patel Department of Information Technology, Faculty of Technology & Engineering, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology (CHARUSAT), Changa, Gujarat, India

Ravneet Kaur Chandigarh University, Mohali, India

M. Saddam Hossain Khan Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

Vaishali A. Kherdekar MIT Arts Commerce & Science College, Alandi(D), Pune, Maharashtra State, India

Ketan Kotecha Artificial Intelligence and Machine Learning Department, Symbiosis Institute of Technology, Symbiosis International (Deemed) University, Pune, India;
Symbiosis Centre of Applied AI (SCAAI), Symbiosis International (Deemed) University, Pune, India

Bandaru Bhaskar Sai Madhava Krishna Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Sanika Kulkarni Department of Information Technology, MKSSS's Cummins College of Engineering for Women, Pune, Maharashtra, India

Tejas Kulkarni Vishwakarma Institute of Technology, Pune, India

Varad Kulkarni Vishwakarma Institute of Technology, Pune, India

Yash Kulkarni Vishwakarma Institute of Technology, Pune, India

Harshal Kullarkar Vishwakarma Institute of Technology, Pune, India

Aman Kumar Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

Rajeev Kumar Moradabad Institute of Technology, Moradabad, India

Santosh Kumar Department of Computer Science, ERA University, Lucknow, Uttar Pradesh, India

Tarun Kumar CPDM, Indian Institute of Science, Bengaluru, Karnataka, India

Rahul Kumare Vishwakarma Institute of Technology, Pune, India

Ritika Kumari Indira Gandhi Delhi Technical University for Women, Delhi, India;
USICT, GuruGobindSinghIndraprasthaUniversity, New Delhi, India

Jay Kumawat Vishwakarma Institute of Technology, Pune, India

Samuli Laato University of Turku, Turku, Finland

D. Lakshmi Narayana Reddy Department of Computer Science and Engineering, Anantha Lakshmi Institute of Technology and Sciences, Anantapur, Andhra Pradesh, India

Ville Leppänen University of Turku, Turku, Finland

H. Mahaan Mithrar Department of Information Technology, Rajalakshmi Engineering College, Chennai, India

Maisha Mahajabin Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

R. Mahaveerakannan Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India

Nusrat Maisha Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

Jeet Matalia Smt. Kundaben Dinsha Patel Department of Information Technology, Faculty of Technology & Engineering, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology (CHARUSAT), Changa, Gujarat, India

Sudhanshu Maurya Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune, India

Pradeepta Mishra REVA Academy for Corporate Excellence (RACE), REVA University, Bengaluru, India

Md. Mojahidul Islam Department of Computer Science and Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India

Aishwarya Mondal Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Suchitra Morwadkar Department of Information Technology, MKSSS's Cummins College of Engineering for Women, Pune, Maharashtra, India

B. N. Motagi AICRPG, MARS,UAS, Dharwad, Karnataka, India

Pranjal Mundhada Shri Ramdeobaba College of Engineering and Management, Nagpur, India

Atharv V. Munot Department of Computer Engineering, COEP Technological University, Pune, India

Sirajbhai Abbasbhai Nagalpara Department of Computer Science, HNGU, Patan, Gujrat, India

Sachin Naik Symbiosis Institute of Computer Studies and Research (SICSR), Symbiosis International (Deemed University) (SIU), Pune, Maharashtra State, India

Om Nankar Artificial Intelligence and Machine Learning Department, Symbiosis Institute of Technology, Symbiosis International (Deemed) University, Pune, India

Vishal Narvani GLS University, Ahmedabad, India

Pranta Nath Nayan Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

Bhakti Palkar K. J. Somaiya College of Engineering/Computer, Mumbai, India

H. Summia Parveen Department of CSE, Sri Eshwar College of Engineering, Coimbatore, India

Bhavesh M. Patel Department of Computer Science, HNGU, Patan, Gujrat, India

Kanubhai K. Patel Charotar University of Science and Technology, Changa, India

Natvar Sardarbhai Patel Department of Computer Science, HNGU, Patan, Gujrat, India

Priyanka Patel Smt. Kundaben Dinsha Patel Department of Information Technology, Faculty of Technology & Engineering, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology (CHARUSAT), Changa, Gujarat, India

Rudra Patel Smt. Kundanben Dinsha Patel Department of Information Technology, Faculty of Technology, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology Changa, Anand, Gujarat, India

Nitin Pathak Chandigarh University, Mohali, India

Shambhavi Patil Artificial Intelligence and Machine Learning Department, Symbiosis Institute of Technology, Symbiosis International (Deemed) University, Pune, India

S. Poonkuzhali Department of CSE, Centre of Excellence in Assistive Technology, Rajalakshmi Engineering College, Chennai, India

C. S. Prantha Department of Computer Science and Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India

Priyanka Indira Gandhi Delhi Technical University for Women, Delhi, India

M. N. Pushpalatha Ramiah Institute of Technology, Bangalore-54, India

Abdur Rahman Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

R. Rajagopal Alliance University, Bangalore, Karnataka, India

Samruddhi Rajole Department of Information Technology, MKSSS's Cummins College of Engineering for Women, Pune, Maharashtra, India

S. B. Rammya PES University, Bengaluru, Karnataka, India

Deepika Ranolia Om Sterling Global University, Hisar, Haryana, India

Akshath Rao Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Annam Takshitha Rao Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

Sampsa Rauti University of Turku, Turku, Finland

Kakanuru Yoga Sreedhar Reddy Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Nandimandalam Saketh Reddy Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

A. S. Remya Ajai Department of Electronics and Communication Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

Nesh Rochwani Smt. Kundanben Dinsha Patel Department of Information Technology, Faculty of Technology, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology Changa, Anand, Gujarat, India

S. Rohithkumar Department of Information Technology, Rajalakshmi Engineering College, Chennai, India

V. V. N. Sai Rajeshwar ACE Engineering College, Hyderabad, India

Adrinil Santra Haldia Institute of Technology, Haldia, West Bengal, India

Suchinta Satish Ramiah Institute of Technology, Bangalore-54, India

M. Senbagavalli Alliance University, Bangalore, Karnataka, India

Rima Shah Research Scholar, Faculty of Social Sciences and Humanities (FSSH), Ganpat University, Mehsana, Gujarat, India;
Consultant, School of Computer Science, Dr. Babasaheb Ambedkar Open University, Ahmedabad, Gujarat, India

Isha Shetye Department of Information Technology, MKSSS's Cummins College of Engineering for Women, Pune, Maharashtra, India

Rigved Shirvalkar Department of Electronics and Communication Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

H. R. Shreya PES University, Bengaluru, Karnataka, India

J. B. Simha REVA Academy for Corporate Excellence (RACE), REVA University, Bangalore, India

C. Sindhu Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Shivam Kumar Singh Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Rohan Sriharsha Ramiah Institute of Technology, Bangalore-54, India

Amy Joyce Suganthama V REVA Academy for Corporate Excellence (RACE), REVA University, Bengaluru, India

C. S. Sunidhi PES University, Bangalore, India

Shashwath Suvarna Department of Computing Technologies, School of Computing, SRM Institute of Science and Technology, Kattankulathur, India

Amit Thakkar Department of Computer Science and Engineering, Chandubhai S. Patel Institute of Technology (CSPIT), Charotar University of Science and Technology (CHARUSAT) Changa, Anand, Gujarat, India

Chandan Thakur K. J. Somaiya College of Engineering/Computer, Mumbai, India

Ankit Tiwari Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Rashedul Amin Tuhin Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

Md. Mohsin Uddin Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh

Nilay M. Vaidya Charotar University of Science and Technology, Changa, India

Amol Vibhute Symbiosis Institute of Computer Studies and Research (SICSR), Symbiosis International (Deemed University), Pune, India

Vrince Vimal Graphic Era Hill University, Graphic Era Deemed to Be University, Dehradun, India

R. Vinoth Kumar Department of Computer Science and Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India

Hemant N. Yadav Smt. Kundanben Dinsha Patel Department of Information Technology, Faculty of Technology, Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology Changa, Anand, Gujarat, India

Nilima Zade Department of Computer Science and Engineering, Symbiosis International (Deemed University), Pune Campus, Symbiosis Institute of Technology, Lavale, Mulshi Pune, Maharashtra, India

A Structure for Forecasting Stomach Cancer Using Deep Learning and Advanced Tongue Characteristics

D. Lakshmi Narayana Reddy, R. Mahaveerakannan, Santosh Kumar, J. Chenni Kumaran, and M. Bhanurangarao

Abstract The global health problem of gastric cancer has significantly impacted people's daily lives. Early detection and rapid treatment of stomach cancer patients considerably contribute in protecting human health. Routine gastric cancer tests, however, are time-consuming and run the risk of consequences. The performance of the current tongue segmentation algorithms in a typical context is good. Tongue segmentation is quickly completed in an open environment using a revolutionary deep neural network tongue segmentation technique that is appropriate for mobile devices. Given that the images taken by this device also include non-tongue areas, a special deep neural network was used to segment the tongue in order to reduce interference with feature extraction. Intelligent tongue diagnosis requires accurate tongue picture segmentation. In this manner, linkages between the nine recovered tongue traits and the disease as well as statistical and deep learning approaches were used to construct a forecast structure to predict gastric cancer. The experimental results demonstrated the suggested framework's 93.6% accuracy rate for threat detection. A method for investigating the connections between cancer of the stomach and tongue traits is provided by a structure to forecast gastric cancer that was developed by fusing statistics and deep learning approaches. With the use of this framework, early identification of stomach cancer is considerably simpler.

Keywords Novel deep neural network · Non-intrusive deep learning · Tongue characteristics · And prediction structure for stomach cancer

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D. Lakshmi Narayana Reddy
Department of Computer Science and Engineering, Anantha Lakshmi Institute of Technology and Sciences, Anantapur, Andhra Pradesh, India

R. Mahaveerakannan (✉) · J. Chenni Kumaran · M. Bhanurangarao
Department of Computer Science and Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India
e-mail: mahaveerakannanr.sse@saveetha.com

J. Chenni Kumaran
e-mail: chennikumaranj.sse@saveetha.com

S. Kumar
Department of Computer Science, ERA University, Lucknow, Uttar Pradesh, India

T. Senjyu et al. (eds.), *Smart Trends in Computing and Communications*, Lecture Notes in Networks and Systems 949, https://doi.org/10.1007/978-981-97-1313-4_1

1 Introduction

An important portion of annual fatalities is caused by stomach cancer, one of the most prevalent types of cancer in people [1]. A small number of people with early-stage gastric cancer [2] experience vague signs including epigastric pain and burp. However, most of these individuals are asymptomatic. Gastroscopy is the technique that is most frequently used to find gastric cancer [3]. The doctors determine the severity and location of the lesion by evaluating the state of the gastric mucosa. To recognize worrisome lesions, doctors must have substantial knowledge and experience, and their working conditions (such as alertness) may have an impact on the diagnosis [4]. Researchers can now use artificial intelligence to improve gastroscopy thanks to recent technology advancements [5, 6]. Artificial intelligence technology evaluates the severity of the lesions more quickly and accurately than specialized endoscopists. The procedure of a gastroscopy, however, is invasive and may result in side effects such bleeding and perforation [7]. The decision to undergo a gastroscopy to look for gastric cancer is reluctance among patients with minimal symptoms.

A non-intrusive diagnostic method called tongue diagnosis can be used to quickly determine a patient's condition. The physical characteristics of the tongue are related to the functions of the organs as well as their physical state [8]. By examining the patient's changes in tongue features, practitioners can create treatments for the related condition and determine the severity of lesions [9]. Digital analysis of tongue features has led to the development of quick and easy disease detection methods [10–12]. The investigation of the relationship between tongue features and illnesses has become more objective thanks to the widespread usage of artificially intelligent tools [13] in the medical field. The ability to record physical details that are invisible to the human eye has been achieved through the use of image processing [14]. To automatically recognize and learn tongue traits, deep learning [15] has been used. Links between tongue characteristics and illnesses have been established to suspect diseases including cancers of the breast [16], hypertension [17], and stomach cancer [18].

Helicobacter pylori and other oral bacteria have been linked to gastric cancer, according to research [19, 20]. In the literature, the tongue coating thickness and high-throughput sequencing have both been used to analyze people with stomach cancer's oral microbiome [21, 22]. However, this technique has a restricted ability to detect subtle changes and is often susceptible to variations in microbial concentration. Using tongue characteristics and artificial intelligence approaches, Gholami et al. [23] suggested a technique to detect stomach cancer. In identifying patients from healthy people, the suggested technique had a high level of accuracy. To accomplish non-invasive prediction of patients with gastric cancer, a framework utilizing Efficient Net [24] is built. Figure 1 depicts the finer points of the overall framework. It offers a method for examining how features of the tongue and gastric cancer are related.

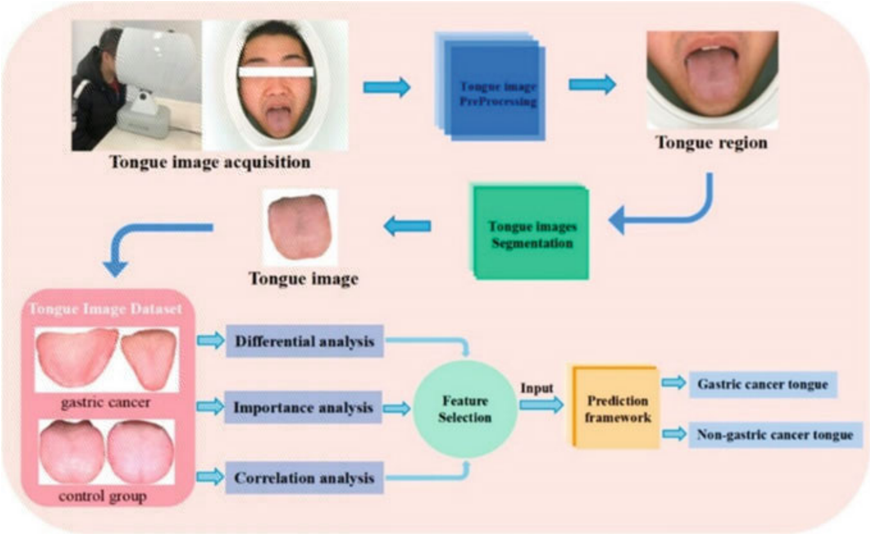

Fig. 1 Overview of our framework

2 Related Works

The likelihood of getting stomach cancer is high. Reduced mortality rates for people with stomach cancer are a result of early identification of the disease. The doctor can observe the changes in the gastrointestinal mucosa and the extent of the lesions as one of the efficient approaches to identify stomach cancer. Researchers [25–27] developed detection of stomach cancer algorithms to use artificial intelligence to detect gastric endoscopic cancer pictures in order to get around these constraints. The model was developed using a substantial sample of endoscopic photos of gastric cancer that were interpreted by certified medical experts. The breath monitoring approach was found to be a very good option for stomach cancer screening as the consequence of the findings. The breathing collecting method, the patient's physiological state, the testing environment, and the analysis method are all variables that can affect the outcomes of breath analysis [28, 29].

Jiang et al. [30] developed a non-intrusive extremely accurate detection algorithm for stomach cancer using variables like age, gender, and a person's behavioral lifestyle. Overall accuracy for the model in the test set was 85.7%. Zhu et al. [31] also employed machine learning methods to create a nonsurgical forecast algorithm for the risk of stomach cancer. It has not been done much, nevertheless, to use tongue pictures to create illness prediction models [11, 32, 33]. A 91% accurate prediction model for gastric cancer was created by Gholami et al. employing tongue lint and tongue pigment [23]. However, they only looked at the connection between tongue pigmentation and tongue lint, not the connection between other aspects of the tongue and gastric cancer.

Fig. 2 Image-taking of the tongue is shown in Fig. 2. The subjects extended their natural tongues during the collection while placing their mandibles on the equipment

3 Methods

A device to capture photographs of patients' tongues with stomach cancer and wholesome participants in hospitals to make sure the proposed framework had therapeutic use. Non-tongue regions like the face and the instrument can be seen in the photos taken using the tongue image acquisition tool. In order to increase the effectiveness of picture segmentation, non-tongue regions are considerably minimized during image preprocessing. Following the insertion of the cleaned-up tongue images into the framework for predicting gastric cancer, the final predictions were produced.

3.1 Date Sources

From January 2021 to August 2022, information on 703 individuals of various ages was gathered from Shanxi Cancer Hospital and the Affiliated Hospital of Shanxi University of Traditional Chinese Medicine. The collection includes 600 tongue photographs of non-stomach cancer subjects, such as healthy people and patients with different diseases, together with 103 tongue pictures of people who had stomach cancer. It is unquestionably known what ailments these people had. Under the direction of skilled medical professionals, the patient's tongue photos were taken. The participants were set up to face the device while naturally extending their tongues (Fig. 2).

3.2 Date Preprocess

Image of the acquired tongue had a resolution of 3264 by 2488 pixels and 96 dots per inch on both the horizontal and vertical axes. The deep learning network has to spend a lot of time and energy processing photos of the tongue at high quality that do not include the tongue. The area of non-tongue areas was significantly reduced extracting the tongue region approach suggested by Li [34]. The deep learning network's computational load was decreased, while the effectiveness of subsequent tongue segmentation was increased. To avoid overfitting of the prediction model brought on by imbalanced data, the quantity of tongue pictures was raised to 4374 via data augmentation [35].

The tongue image capture instrument typically captured photos that included other regions in addition to the tongue, like the lips and teeth. To reduce the impact of non-tongue regions on the analysis that followed, the images' tongue portion was divided. Automatic tongue segmentation systems currently in use can be divided into two groups: systems for segmentation based on simpler techniques, like the region-growing approach and the thresholding method, as well as structures for categorization constructed with deep learning techniques. Simpler segmentation methods commonly misidentify these regions as the tongue because they are blind to the hue of the areas near the tip of the tongue [36–38]. Clinically acquired tongue photos were utilized as the dataset for segmentation in this step, and the Deeplabv3+ [39] network, which was chosen for the tongue identification test, is based on deep learning.

3.3 Tongue Image Segmentation

On an encoder–decoder architecture, the Deeplabv3+ network is built. Multiple concurrently dilated convolution layers and a network for extracting features make up the encoder portion. A backbone network called MobileNetV2 [40] is utilized. High-level semantic features are created in the encoder portion using the image features that have been retrieved. The training set, validation set, and test sets of the information employed to separate the tongue were divided into three groups in a ratio of 7:2:1. As a starting weight, ImageNet's MobileNetV2 network weight was used. During the training phase, the model was optimized using the Adam optimizer [41]. The characteristics of the tongue and the retrieval of those attributes (Fig. 3).

In order to examine the differences between the tongues of people with stomach cancer and people without the disease, nine tongue traits were retrieved using the combined expertise of multiple experts. The following sentences contain a list of the extracted tongue traits.

1. There are three types of tongue shapes: fat, thin, and normal;
2. Tongue with a toothmark: toothmark and normal;
3. On the tongue, there are spots and prickles in a normal range;
4. Standard, dry saliva;
5. There are two different tongue coating densities;
6. A typical and oily tongue covering;
7. Pale white, crimson, red, and deep red oral color;
8. White and yellow oral covering;

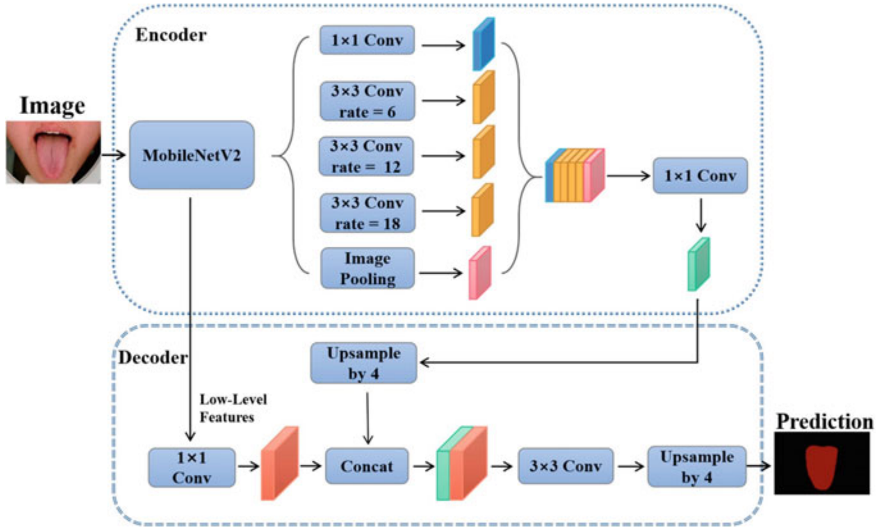

Fig. 3 Network of Deeplabv3+. The high-level and low-level semantic properties of the oral picture are extracted and combined using the Deeplabv3+ structure

9. Oral fissure: a typical fissured oral.

Statistical methods were used to compare the variations in oral characteristics between the group of patients with the control group and stomach cancer. Figure 4 displays the cross-plot of tongue characteristics among the two categories. Saliva, the thickness of the tongue coating, the depth of the tongue fissure, the texture of the tongue coating, and the presence of tooth marks were all clearly different between the two groups. Patients with gastric cancer had significantly different tongue weights from those in the control group in terms of these characteristics.

Table 1 illustrates the variations in tongue characteristics between the control group and patients with stomach cancer. Comparing the control group and the patients with stomach cancer, there were five tongue traits that were substantially different (p-value < 0.001): the tongue with dental marks, spit, the depth and quality of the tongue coating, and the form of the tongue. (51.44% versus 33.81%, 0.001 p-value 0.004); individuals with stomach cancer had a substantially higher percentage of the yellow tongue coating than those in the control group. Additionally, the percentage of spots and prickles on the tongue was considerably higher in patients with gastric cancer than in the control group (36.87% versus 24.15%, $0.001 < p$-value 0.004). Both the color of the tongue and the presence of a tongue fissure were not significantly different between patients with stomach cancer and the control group (p-value $>$ 0.004).

The significance of each tongue feature was determined using the XGBT method [42]. Measured in terms of feature importance, each input feature's contribution to the model's identification outcome can be emphasized, together with the feature's applicability to the goal. Lower-scoring features were eliminated, and higher-scoring

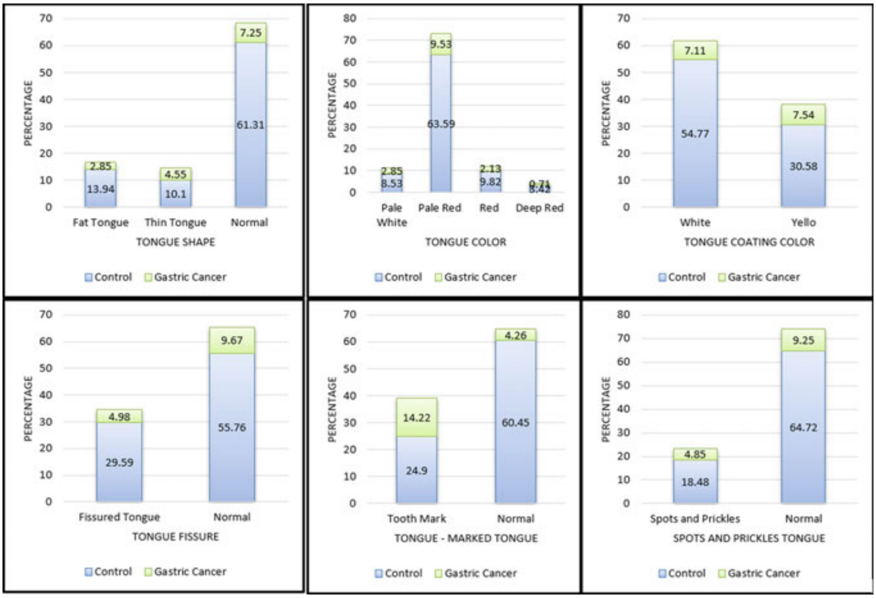

Fig. 4 Tongue traits that differ between those with and without gastric cancer. Gastric cancer patients are represented by the green part in the cross-plot, whereas healthy subjects are represented by the orange section

features were kept. Methods for determining the significance of certain features by removing tongue features that affected prediction, researchers improved the neural network model's computational efficiency and accuracy. This has led to a decrease in the number of characteristics that were entered into the neural network model. The findings of the tongue features are important, as shown in Fig. 5. The model's prediction findings were significantly impacted by the high relevance scores of traits like white tongue, plump tongue, and dry saliva. Because of this, the importance scores of tooth marks, spots, prickles, deep red tongue, yellow tongue coating, and pale white tongue were not high enough to be included in the figure.

The connection between the nine characteristics of the patients' tongues and gastric cancer was then investigated. Two or more features that were correlated were analyzed using correlation analysis to determine how closely the features corresponded. In Fig. 6, the tongue characteristics of individuals with stomach cancer are correlated. The association between two tongue traits is shown in the correlation graph by darker colors. The findings indicate that the fatty tongue layer and the sticky tongue layer had a high probability of linkage; however, the other tongue traits were not substantially correlated. If the correlation between two traits is negative, it means that while one feature of the tongue develops, the other feature also declines.

After the analysis of the oral attributes using statistical methods and artificial intelligence techniques, the oral attributes with major variations, high significance ratings, and large connections among stomach cancer patients and the control group

Table 1 Stomach cancer patients and healthy controls were compared in terms of tongue characteristics

Tongue features (*n*, %)		Control $n = 600$	Stomach cancer $n = 103$	Number of features *p*-value
Oral shape	Fat oral	96 (83.04%)	18 (16.93%)	116 (16.77%)
	Thin oral	69 (68.92%)	30 (31.05%)	102 (14.63%) < 0.001
	Normal oral	430 (89.41%)	49 (10.56%)	480 (68.54%)
Oral color	Pale white	58 (78.94%)	14 (21.03%)	74 (10.80%)
	Pale red	445(86.93%)	65 (13.02%)	512 (73.10%) 0.22
	Red	67 (82.12%)	13 (17.84%)	82 (11.93%)
	Deep red	22 (82.74%)	3 (17.22%)	27 (4.11%)
Oral coating color	White	383 (88.50%)	48 (11.45%)	433 (61.86%) 0.0036
	Yellow	213 (80.21%)	51 (19.74%)	266 (38.10%)
Spit	Dry	91 (56.70%)	69 (43.27%)	162 (23.31%) < 0.001
	Normal	505 (94.04%)	30 (5.92%)	537 (76.65%)
Oral film	Thick	239 (75.53%)	76 (24.43%)	317 (45.36%) < 0.001
Thickness	Thin	357(93.47%)	23 (6.51%)	382 (54.60%)
Oral film	Greasy	306 (78.55%)	82 (21.41%)	390 (55.74%) < 0.001
Texture	Normal	290 (93.87%)	17(6.10%)	309(44.22%)
Oral fissure	Fissured oral	206 (85.62%)	33 (14.41%)	241 (34.55%) 0.98
	Normal	390 (85.20%)	66 (14.76%)	458 (65.41%)
Tooth-marked oral	Tooth mark	173 (63.62%)	98 (36.34%)	273 (39.11%) < 0.001
	Normal	423 (99.32%)	1 (0.71%)	422 (60.86%)
Spots and prickles	Spots and prickles	143 (79.24%)	36 (20.75%)	181 (23.31%) 0.0096
Oral	Normal	453 (87.52%)	63 (12.51%)	518 (73.95%)

were pinned as input attributes for the system for identifying the disease. In addition, a deep learning system for identifying stomach cancer was built using characteristics from the shape of the tongue, saliva, thickness, and texture of the tongue covering (Fig. 7).

The training set, validation set, and test sets were split up into an 8:1:1 ratio from the dataset that was utilized to develop the prediction framework. The official weight has served as the model's initial weight when the Efficient Net network model was trained using the dataset.

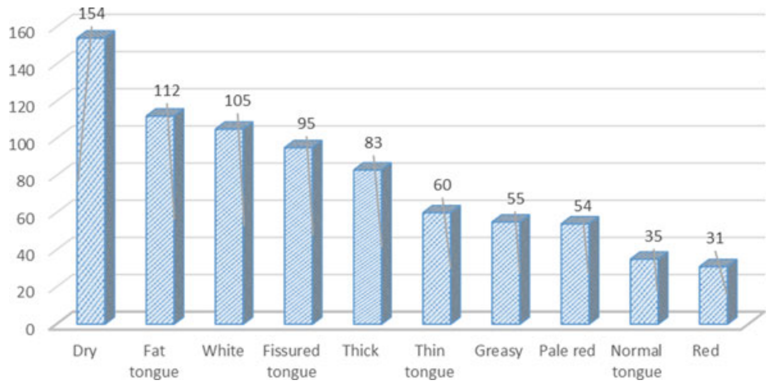

Fig. 5 Importance of tongue characteristics

	Fat tongue	Thin tongue	Normal tongue	Pale while	pale red	red	deep red	White	Yellow	Dry	Thick	Greasy	Fissured tongue	Tooth mark	Spots and prickles
Fat tongue	1	-0.3	-0.5	0.21	0.1	-0.1	-0.1	-0.1	0.1	0.17	0.13	0.17	0.06	-0.1	0.23
Thin tongue	-0.3	1	-0.7	-0.1	-0.2	0.04	0.3	-0.1	0.1	0.27	0.1	-0.1	-0.2	0.12	-0
Normal tongue	-0.5	-0.7	1	-0.1	0.08	0.06	-0.2	0.17	-0.2	-0.4	-0.2	-0.1	0.15	-0.1	-0.2
Pale white	0.21	-0.1	-0.1	1	-0.2	-0	-0	0.07	-0.1	0.07	0.05	0.05	0.15	0.02	0.14
Pale red	0.1	-0.2	0.08	-0.2	1	-0.8	-0.4	-0.1	0.11	0.05	0.11	0.22	-0.1	0.36	-0.2
Red	-0.1	0.04	0.06	-0	-0.8	1	-0.1	0.09	-0.1	-0.1	-0.2	-0.2	0.1	-0.4	0.13
Deep red	-0.1	0.3	-0.2	-0	-0.4	-0.1	1	0.03	-0	0.03	0.11	-0.2	-0.1	0.04	0.17
White	-0.1	-0.1	0.17	0.07	-0.1	0.09	0.03	1	-1	-0.2	-0.3	-0.3	-0.1	-0.1	0.05
Yellow	0.1	0.1	-0.2	-0.1	0.11	-0.1	-0	-1	1	0.19	0.31	0.28	0.05	0.12	-0.1
Dry	0.17	0.27	-0.4	0.07	0.05	-0.1	0.03	-0.2	0.19	1	0.26	0.16	0.04	0.13	0.05
Thick	0.13	0.1	-0.2	0.05	0.11	-0.2	0.11	-0.3	0.31	0.26	1	0.67	0.04	0.19	-0.1
Greasy	0.17	-0.1	-0.1	0.05	0.22	-0.2	-0.2	-0.3	0.28	0.67	0.67	1	0.16	0.21	-0.1
Fissured tongue	0.06	-0.2	0.15	0.15	-0.1	0.1	-0.1	-0.1	0.05	0.04	0.04	0.16	1	-0.1	0.01
Tooth mark	-0.1	0.12	-0.1	0.02	0.36	-0.4	0.04	-0.1	0.12	0.19	0.19	0.21	-0.1	1	-0.1
Spots and prickles	0.23	-0	-0.2	0.14	-0.2	0.13	0.1	0.05	-0.1	-0.1	-0.1	-0.1	0.01	-0.1	1

Fig. 6 Comparison of the characteristics of the tongue in those with gastric cancer

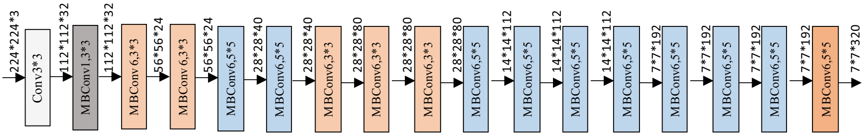

Fig. 7 Baseline network for EfficientNet-B0

3.4 Performance Metrics

Based on the Pytorch deep learning framework, the research was run on a Windows 10 computer with an Intel Core i7-10700 and an NVIDIA GeForce RTX 2060 graphics card.

Four criteria were used in this part to evaluate how well the segmentation technique and framework for predicting gastric cancer worked. Utilizing mean intersection over union (MIoU) and mean pixel accuracy (MPA) measurements, the Deeplabv3+ network's performance was assessed [43]. Precision and F1-score were used to evaluate the categorization accuracy of the structure to forecast stomach cancer. The following are the definitions and formulas for MIoU, MPA, precision, and F1-score.

The prevailing assessment technique for segmentation techniques is MIou. Each class of pixels in the union set has its specific intersection value determined by the expected segmentation and the actual segmentation. In order to calculate MIou, all class ratios are then added together and averaged.

If the image's category count is k (excluding the background), pii and pij are the number of pixels belonging to each category that are expected to be in each respective category.

Pixel precision is the foundation of MPA. The exact ratio of the total number of pixels to the number of pixels correctly anticipated in each class was determined to arrive at the PA. Subsequently, the mean performance average (MPA) was calculated by computing the average of the performance assessments (PAs) for all the classes.

The percentage of samples that the model accurately predicted compared to the total sample is called accuracy.

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}},$$

where TP represents the proportion of correctly identified positive samples, TN represents correctly identified negative samples, FP represents the proportion of falsely positive negative samples, and FN represents the proportion of correctly identified positive samples.

An index used to evaluate a binary classification model's performance is called the $F1$-score. By computing the harmonic mean of precision and recall, it is possible to produce a more balanced metric that balances the two:

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}},$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}},$$

$$F_1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}.$$