An Attention based Expert Inspection System for Smart Scalp

Sin-Ye Jhong[1], Po-Yen Yang[2], Chih-Hsien Hsia[3,*]
[1]National Cheng Kung University, Tainan, Taiwan
[2] The Hong Kong University of Science and Technology, Hong Kong, China
[3] National Ilan University, Yilan, Taiwan
*E-mail: chhsia625@gmail.com

Abstract— **Along with the coming of the beautiful economic era, scalp problems have been valued by the public, which prompts hairdressers to come up, called scalp care services. However, current services are limited by problems such as not automatic, not objective, and not remarkable, which make it unacceptable by the public. Based on the above, this research focuses on the obstacles that hairdressers at home and abroad face and proposes an expert inspection system suitable for scalp problems. Through the biggest key scalp problem, which is using the severity of dandruff to estimate the health condition of the scalp. Besides offering a more effective smart scalp inspection process, this method can also let hairdressers and customers to track their scalp problems easily. In the future, we expect to reduce the human resource stress on hairdressers and enhance customers' trust on the scalp care services by the offered smart health inspection. As results, compared to recent research, it has been shown that the method proposed by this research can achieve an accuracy of 85.03%.**

I. INTRODUCTION

Along with the progress of economy and technology, the demand for quality of life doesn't limit to food, clothes, housing, transportation, and entertainment, people also pay more attention to beauty and health, which leads to the new emerging industry of "Beautiful economy," and this has prompted the thriving of fashion & beauty service industry as well. According to the newest information by the FIND team in the Institute for Information Industry (III). There are about 30,665 domestic hairdressing, beauty, and bodybuilding shops, and their annual revenue can be up to NTD$ 37.9 billion, among these shops, there are approximately 21,915 hairdressing stores and their annual revenue is up to NTD$ 24.8 billion, which makes up 60% of the revenue of the whole beauty & fashion industry in Taiwan. However, the increasing market scale has also brought a new operation mode to this moderate competitive market. In order to enhance brand competitiveness and robust customers' expertise regarding scalp health, hairdressing shops nowadays are not only restricted to hairdressing services like washing, cutting, dying, hair care, and perming, some shops have been thinking of collaborating with hospitals and launching scalp care services [1]. In order to deal with patients' scalp issues, these hairdressing shops have aided customers to find hairdressing products that are suitable for themselves through hiring dermatologists or licensed professional scalp therapists to distinguish the health situation for the customers' scalp and offering a series of therapy regarding different scalp issues.

Recently, affected by dietary changes, environment contamination, miserable lifestyle, and pressure, almost every person nowadays has scalp problems. Common scalp issues include seborrhoeic dermatitis, olliculitis, ry seborrhea, hair loss, oily seborrhea, allergy, Hyperkeratosis etc., and among those issues, at least 30% belong to serious scalp patients and have hair loss hesitations [2]. Although hair and scalp disorders usually will not cause serious physical discomfort, it has a huge effect psychologically. In the lives of modern people, the function of hair is not only for keeping warm and protecting one's head originally, but it also has a crucial effect on the outward appearance. Serious hair problems may affect faith and lead to social barriers. Besides, in some situations, the changes of one's scalp may be a sign for some serious physical illness, hence, physiotherapy services mainly focusing on healing scalp is an imperative trend.

From the above-mentioned problems, we can observe that the current scalp therapy service is restricted by issues such as "not objective, nonautomation, not significant," which made related business unable to be promoted, hence, how to enhance the service quality through the intervention of technology has become an urgent and unavoidable crucial topic. As a matter of fact, this paper focuses on the needs for the scalp therapy services offered by hairdressers, and start from the scalp therapists' scalp health inspection, combining with computer vision (CV) techniques, and the concepts of artificial intelligence of things (AIoT) to build an inspection expert system for smart scalp (IE3S).

II. RELATED WORK

Recently, along with the rise of health consciousness, the public has started to sense the importance of scalp issues, and researchers have done related research on scalp issues in succession. Elewski et al. [3] is the first person to analyse scalp problems caused by different elements, which includes Tinea capitis and seborrheic dermatitis affected by Superficial mycoses, Pediculosis capitis affected by pesticide contamination, and Psoriasis belonging to inflammatory disease, since the above mentioned problems all have similar lesions such as dandruffs, inflame, hair loss, and prone to

itching, which results in difficulties in recognizing the cause of the problem when doing therapy, hence, with the support of microscope, it described a way of recognition for various illness features and built an appropriate therapy method. Continuing previous research, Grimalt et al. [4] changed to use videodermoscopy to analyze common features of scalp problems, besides analyzing the cause of the problem, he once again parses common scalp issue features shown in videodermoscopy and formulated corresponding treatment strategies. Besides recognizing the features of illness and related research on treatment strategies, Kim et al. [5] also utilized microscope image analysis to assess the condition of hair and scalp and used a manual statistical way to define the severity criterion. Ross et al. [6] utilized videodermoscopy to observe scalp issues, through high magnification resolution, clinical features can be clearly visible to the naked human eyes, which proved the feasibility of recognizing hair issues with the use of videodermoscopy. It is observable from the research done by predecessors that most scalp illness feature judgement can be determined by visual method, with the support of high magnification videodermoscopy, medical personnel can distinguish scalp illness from various image characteristics and treat it properly.

However, such a manual diagnosis method often leads to different extent of errors due to long term diagnose fatigue and subjective consciousness. Hence, there are scientists gradually focusing on researching subjects related to scalp issues, hoping to support medical personnel through scientific ways to analyse and distinguish scalp issues to enhance medical service quality and diminish the diagnosis pressure of medical personnel.

In this research, based on the severity index of two main scalp lesions, we propose a scalp health inspection algorithm based on CV and deep learning (DL), through Attention module to enhance detail information of scalp lesions, and using Spinal FC architecture to diminish gradient loss problem and lower the excessive classify computation to resolve the insufficiency of traditional scalp analysis and reach the goal of automation scalp health inspection.

III. Proposed Method

This work has gone through detailed literature exploration and analysis, analysing a method to improve and enhance the past techniques used in multiple researches and lastly combining cloud computing techniques to achieve on Raspberry Pi embedded platform. It is research direction can be separated into three parts: *1)* scalp images collection, *2)* scalp lesions classification model architecture, and 3) cloud computing techniques.

A. Scalp lesions classification model architecture

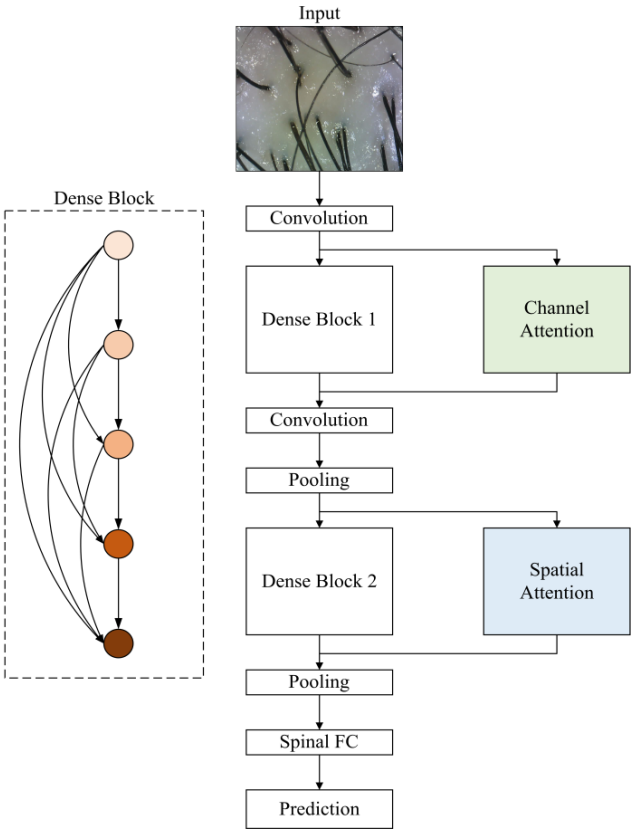

Fig. 1 Proposed scalp lesions severity classification model.

This research referenced the classic model DenseNet [7], where the proposed classification model architecture, is shown in Fig. 1. For scalp lesions classification mission, most scalp lesion images have lots of background noise and the features are extremely tiny, which made some classic natural imaging models unable to effectively extract scalp lesions and that led to an unstable detection effect for the model. In order to resolve this problem effectively, this research added attention mechanisms into the model, Convolutional block attention module (CBAM), as shown in Fig. 2. CBAM is composed of two attention mechanisms, channel attention mainly lets the model focus on meaningful features, which can effectively separate tiny and little difference lesions, this research adopted two ways to extract feature information, which are global average pooling layer and max pooling layer, it gets channel attention features through two lesions passing through one Sigmoid activation function and multiply by the original feature; while space attention let the model being able to be more aware of regional features on the feature image, which made it easier for the model to extract the features it need. Via CBAM, the model's expression ability will be enhanced for features of interest and be more focused on lesion areas that need handling. Another point worth noticing is that in order to effectively diminish unnecessary computations and deep model gradient loss problems of the fully connected (FC) layers, we have changed the FC layers

and classification layers to Spinal FC layers, by entering step by step can not only avoid unnecessary neural connection but lower the problem of model being not effectively caused by model gradient loss.

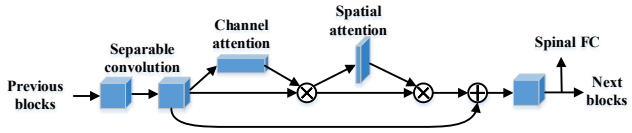

Fig. 2 CBAM module diagram.

B. Cloud computing techniques

Aside from the first and foremost accuracy for analysing scalp problems, human-computer interaction reaction time is also one of the factors when considering whether to use the inspection system. Though the accuracy can be enhanced via the proposed deep learning model in this research stated above, it will result in higher computation complexity. Hence, this research imported cloud computing techniques to diminish a possible situation where the reaction time is too long. Distributed computing and the concept of virtualization has been highly valued recently, cloud computing is a new application of distributed computing, by means of the internet to automatically dismantle a huge computing process procedure to countless smaller sub procedure, then hand over to a gigantic system built up by multiple servers, through searching and computing analysis, then send the processed result back to the user end. As a matter of fact, distributed computing is dividing a large working area into small parts and handing it over to multiple computers to do computation respectively, then collect all the results. Currently cloud operators on the market include Amazon web service (AWS), Microsoft Azure from Microsoft, and Google cloud platform from Google, besides efficiency and price, security is also one important considering factor, lots of cloud provider provide abundant rules, technologies, and control options to strengthen integral security condition and assist in protecting information, applications, and basic structure from the violation of potential threat. Based on the above-mentioned considerations, this research built its fundamentals on the cloud computing platform provided by HIS-LAB from Taiwan University of Science and Technology, it is efficiency is equivalent to a Microsoft Azure Nc6 virtual machine, via secure shell (SSH) to connect between local and cloud counterparts. Through this cloud computing technique, high price hardware equipment build, and maintenance fee can be exempted while still able to access user information, and possess powerful computing ability of cloud computing.

IV. Experiment Result and Comparison

To achieve in life and validate the feasibility of this research, this research adopt USB mobile digital microscope to capture scalp images and input into Raspberry Pi, then upload the image to the lab's cloud server to process the information and algorithm, and then resend the analysis result back to Raspberry Pi, where it will show the current patient's scalp condition based on resend information, which includes instant scalp area score, average scalp score, and scalp health condition assessment result. Then, finish and mock realistic therapy service situations. The embedded system and cloud server specifications are shown in Tables 1 and 2, respectively.

Table 1. Raspberry Pi system specification sheet.

CPU	ARM Cortex-A53 1.4 GHz
Operation system	Raspbian Stretch
Memory	1GB LPDDR2
Programming languages	C++、Python

Table 2. Cloud server specification sheet.

CPU	Intel® Core™ i7-10700 2.90 GHz
GPU	GeForce RTX 2080 Ti
Operation system	Windows 10
Memory	32GB DDR4

Classification accuracy is a vital index for scalp inspection, a higher score means the classification is more accurate and the system is more stable. This research reached the best parameters by keeping training and testing the learning model, table 3 is a comparison of the classification accuracy of each method. Compared with former scalp classification algorithms and relevant classic deep classification models, this research has a higher classification accuracy.

Table 3. Scalp issue classification method comparison.

Methods	Accuracy
Wang *et al.* [8]	62.81%
DenseNet [7]	79.24%
EfficientNet B7 [9]	83.29%
This work	85.03%

V. Conclusion

This research proposed a new smart scalp inspection system, besides using CBAM and Spinal FC to enhance and improve scalp lesions classification problems, we have also combined a cloud computing technique, AIoT design architecture, to let the model be applied more in realistic circumstances. Compared with recent literature, it can be seen that the method proposed in this research is able to achieve a better classification performance, reaching 85.03% in accuracy and its cloud service.

Acknowledgment

Frist, the authors would like to thank the anonymous reviewers of their paper for the many helpful suggestions. Then, this development has done actual field and professional clinical research with one of the Taiwan scalps caring companies, MacroHi Ltd., and the dermatology sector of En Chu Kong Hospital. Finally, this work was supported by the

Ministry of Science and Technology of Taiwan, R.O.C. under grant number MOST 110-2221-E-197-027.

REFERENCES

[1] Dermatology sector of en chu kong hospital [Online] Available: https://reurl.cc/x0dNaN

[2] W.-J. Chang, M.-C. Chen, L.-B. Chen, Y.-C. Chiu, C.-H. Hsu, Y.-K. Ou, and Q. Chen, "A mobile device-based hairy scalp diagnosis system using deep learning techniques," *IEEE Global Conference on Life Sciences and Technologies*, 2020, pp. 145-146.

[3] B. E. Elewski, "Clinical diagnosis of common scalp disorders," *Journal of Investigative Dermatology Symposium Proceedings*, vol. 10, pp. 190-193, 2005.

[4] R. Grimalt, "A practical guide to scalp disorders," *Journal of Investigative Dermatology Symposium Proceedings*, vol. 12, pp. 10-14, 2007.

[5] H. Kim, W. Kim, J. Rew, S. Rho, J. Park and E. Hwang, "Evaluation of hair and scalp condition based on microscopy image analysis," *International Conference on Platform Technology and Service*, 2017, pp. 1-4.

[6] E. K. Ross, C. Vincenzi and A. Tosti, "Videodermoscopy in the evaluation of hair and scalp disorders, "J*ournal of the American Academy of Dermatology*, vol. 10, vol. 55, pp. 799-806, 2006.

[7] Huang et al., "Densely connected convolutional networks," *IEEE Conference on Computer Vision and Pattern Recognition*, 2017, pp. 4700-4708.

[8] W. –C. Wang, L. -B. Chen, and W. -J. Chang, "Development and experimental evaluation of machine-learning techniques for an intelligent hairy scalp detection system," *Applied Sciences*, vol. 8, no. 6, pp. 853, 2018.

[9] M. Tan and Q. V. Le, "EfficientNet: rethinking model scaling for convolutional neural networks," *IEEE International Conference on Machine Learning*, 2019.