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PASSION Dermatology: à pilot study for an intelligent self-assessment educational system.

Andriambololoniaina Faly Herizo[1,2], Randriamanalina Rojo Nofodiantsoa[1], Gottfrois Philippe[3], Rakotoarisaona Mendrika Fifaliana[8], Traoré Ibrahim[6], Mavura David[7], Ravonimanantsoa Ndaohialy Dana[2], Ratovohery Andry Nirilalaina[1], Randriamboavonjy Rado Lalao[1], Ratsimbazafimahefa Rahantalalao Henriette[1,4], Schmid-Grendelmeier Peter[5], Rapelanoro Rabenja Fahafahantsoa[1,2,8], Ravonimanantsoa Ndaohialy Manda-Vy[1,2], Hsu Cristophe[3], Navarini Alexander[3]

[1]Laboratoire d'Accueil et de Recherche en santé publique spécialisé en Technologies de l'Information médicale et de la Communication (LARTIC), University of Antananarivo.
[2]Laboratoire Réseau, Intelligence Artificielle, Multimédia, Sécurité et Système d'Informations (RIMSS), Ecole Doctorale en Sciences et Techniques de l'Ingénierie et de l'Innovation (ED STII), Ecole Supérieure Polytechnique, University of Antananarivo.
[3]Département Dermatologie, Hôpital Universitaire de Bale, Suisse.
[4]Public Health Department, Faculty of Medicine, University of Antananarivo, Madagascar.
[5]Département Dermatologie, Hôpital Universitaire de Zurich
[6]Département Dermatologie, Hôpital de Guinée Conakry.
[7]Regional Dermatology Training Centre, Kilimanjaro Christian Medical Centre, Moshi, Tanzania
[8]Société Malgache de Dermatologie, CHU Joseph Raseta Befelatanana
Corresponding author : Andriambololoniaina Faly Herizo
Address : Ecole Doctorale en Sciences et Techniques de l'Ingénirie et de l'Innovation. EAD RIMSS, Ecole Supérieure Polytechnique, Antananarivo
Email : herizo.andriambololoniaina@univ-antananarivo.mg
Phone Number : +261 34 14 486 13

Abstract

The alarming shortage of dermatologists in the world poses a real problem in terms of access to medical expertise for the treatment of skin diseases. The PASSION Dermatology project, led by the University of Basel in Switzerland, seeks to provide a solution by combining artificial intelligence with teledermatology. The aim is to develop a Machine Learning algorithm capable of recognising skin lesions with different types of pigmentation, using data from several European, African and Asian countries to form a federated learning system. For Madagascar, which joined the project in 2020, the data is collected by a team of dermatologists via a collaborative teledermatology platform. The team has sent a total of 323 photos of atopic dermatitis/eczema, dermatophytosis, impetigo and scabies to the server. Currently, a local study is being carried out to improve the collection system in order to speed up the volume of data with a view to reaching 1,000 photos per year for model training with local photos for these 5 most common skin diseases in Madagascar. Using the algorithm developed in Switzerland and India, the model was evaluated using a confusion matrix to give a precision/recall performance result of 0.92/0.93 (n =2429). In addition, the Madagascar technical team is looking to improve this model and is currently developing an algorithm that will produce an intelligent computer-guided medical self-learning system, a new challenge for the African continent.

Keywords:

Knowledge Acquisition (computer), Supervised Machine Learning, Dermatology, AI (Artificial Intelligence), Telemedicine.

1- Introduction

In the past five years, Artificial Intelligence has been increasingly of interest to the healthcare sector (Panch et al. n.d.) (Callier and Sandel 2021) in French-speaking developing countries (Gruson 2019). In Madagascar, as in several African countries, dermatology is one of the specialties affected due to the insufficient number of specialists and the increased number of consultation requests, especially in remote areas: according to the latest statistical study in the healthcare sector conducted in 2016, skin conditions account for up to 17.8% of the reasons for outpatient consultations in the Regional and University Hospital Reference Centers. Currently, the overall coverage rate for Madagascar is estimated at one dermatologist per two million inhabitants[1]. Although teledermatology projects have been initiated locally, the problem still persists due to a lack of specialists to respond within a reasonable timeframe to the numerous requests submitted by physicians for a second medical opinion in the teledermatology system. This study, conducted as part of the PASSION Dermatology[2] project, aims to address this problem, which is almost identical worldwide, through the implementation of an intelligent decision support system by combining machine learning and teledermatology for dual purposes: (a) Through the implementation of artificial intelligence in the teledermatology system, the machine significantly assists physicians in diagnosing skin conditions. (b) Machine learning from the experiences and knowledge of dermatologists enables it to acquire the ability to recognize skin conditions, which can then contribute to the education of medical students and physicians through a self-assessment application that helps them become familiar with skin lesions. Madagascar has been involved in this project since 2020 through the Malagasy Society of Dermatology, the Hosting and Research Laboratory in public health specializing in ICT within the Faculty of Medicine, and the Network Laboratory for Artificial Intelligence, Multimedia, Security, and Information Systems within the Higher School of Polytechnics at the University of Antananarivo.

The literature is full of similar research, with results generally evaluated on a single type of skin pigmentation. The question is whether these same models are as effective when trained with other types of skin pigmentation ? To answer this question, the PASSION Project aimed to develop an algorithm capable of recognizing a dermatological lesion under the six phototypes[3]. For this, several countries contribute to the implementation of this work through a federated learning system between a research team in Europe and Asia to work on phototypes 1 and 2, in Madagascar for phototypes 3, 4, and 5, and in Africa for phototype 6. The major challenge of this multi-country project has been to promote cross-border and international collaboration in order to design a diagnostic aid system and strengthen competence in Dermatology worldwide. The aid does not consist of automatically providing a diagnosis but rather contributes to continuous medical education, avoiding any possible travel. In this way, a direct impact on environmental preservation will quickly be palpable due to the dematerialization (Marquet et al. 2019) of the system, and similarly on healthcare economics by avoiding the travel of physicians for continuous training, often outside their practice area (X. Zhang et al. 2021).

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[1] Data consulted from the Human Resources Department of the Ministry of Public Health of Madagascar. June 2022.

[2] Project link: https://www.telederm.ai/

[3] Phototype Scale: 1 for fair skin, 2 for Caucasian skin, 3 for light brown skin, 4 for brown skin, 5 for dark brown skin, 6 for black skin

2- Methods

Each participating country in the Project works on its own dataset. The collection was performed by the dermatologists themselves, with a unique instruction to take photos using a smartphone, using a light green background as much as possible, a focal distance of 25cm for an overall capture of the lesion, and 10 cm for an enlarged capture, with front and profile rotations to increase data.

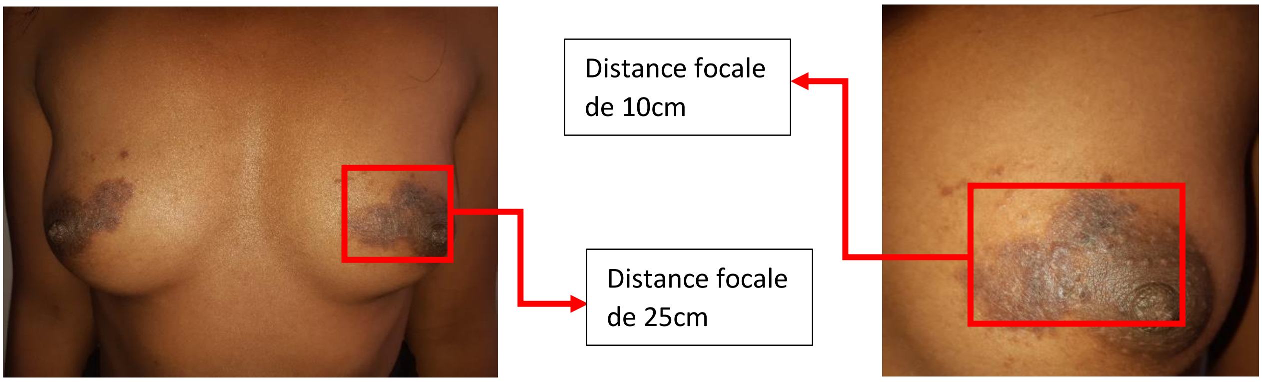

Figure 1: Capturing photographs of skin lesions at a focal distance of 25cm and 10cm

They then classify the photos by phototype and by disease. A double validation by local dermatologists and those from Bale was carried out before admitting each case to the centralized database on an Amazon Web Service (AWS) Cloud server, access to which is completely reserved for its owners. For the collection, informed consent is signed by the patient with their physician before each photo is taken. Each photo is anonymized, no personal patient information is added to the collection system, and the eyes are blurred for facial photos. This is a supervised learning model that involves combining both the morphological analysis of images of dermatological lesions by a convolutional neural network containing five output neurons for the classification of dermatological pathologies (Shanthi et al. 2020) (Hameed et al. 2020) (Zhu et al. 2021a) and the decision tree for clinical and anatomo-pathological elements related to the images to predict a diagnosis (Chan et al. 2020) (Barbieri et al. 2022). For image classification, GELU (Gaussian Error Linear Unit) is used as the activation function with the usual mathematical formula (Hendrycks and Gimpel 2023) :

$$\mathrm{GELU}(x) \quad = 0.5\, x \left(1 + \tanh\left(\sqrt{\frac{2}{\pi}}\left(x + 0.044715\, x^3\right)\right)\right)$$

As well as ViT (Vision Transformer) as a transformer for computer vision tasks (Wu et al. 2020). This algorithm has been jointly developed by the technical teams from Switzerland and India and is currently used for training and evaluating the model's performance. Since last year, Madagascar has been designated to conduct research to improve this model and proceed with training on phototypes 3, 4, and 5, mainly on the dark pigmentation of the Malagasy people, excluding phototype 6 (extremely dark skin), which is not common in Madagascar. With the five pathologies included in the study, such as eczema and atopic dermatitis, scabies, impetigo, fungal diseases, and insect bites, the two-step approach consists of distinguishing the elementary lesions[4] first, and then combining them with clinical elements to predict the diagnosis. The detailed presentation of

4 Typically, closed comedone, open comedone, macule, papule, pustule, crust,...

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the objectives and key points describing the challenges and perspectives of this study have already been published in the Journal of the American Academy of Dermatology (Hsu et al. 2021). For the recognition of these lesions, data annotation is done using manual labeling by drawing outlines around them and assigning corresponding class labels. The next step involves image segmentation to determine the classification of the lesions. This process is described in the conceptual diagram below:

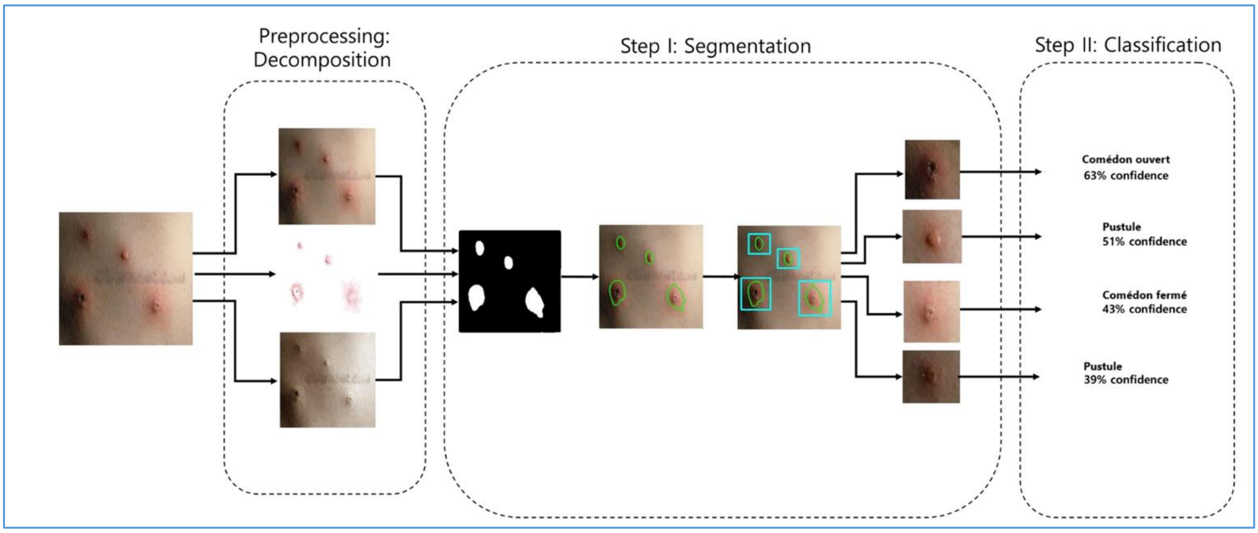

Figure 2: Image segmentation process of dermatological elementary lesions

The Tensorflow library is used for model training. In this year's results for African data, impetigo, scabies, and insect bites were not included due to the insufficient number of collected cases to obtain reliable scores.

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3- Results

For the dataset, a total of 3437 photos were collected in 2021. They were distributed into 5 classes with 2429 photos of eczema, 36 of impetigo, 26 of insect bites, 25 of scabies, 32 of fungal infections, and 887 of other pathologies. During the first six months of data collection for this year, the model's performance evaluation for all the studied pathologies showed more efficient scores compared to those from the previous year. Two models were trained: the first (As) to assess performance for the five pathologies studied in the project, and the second (Bs) for eczema as it is the easiest class to detect based on last year's experience.

For the interpretation of results, precision metrics were calculated based on the following formulas:

$$\text{Accuracy} = \frac{T.P + F.N}{T.N + F.N + T.P + F.P} \qquad \text{Precision} = \frac{T.P}{T.P + F.P} \qquad \text{Recall} = \frac{T.P}{T.P + F.N}$$

where TP = True Positive, TN = True Negative, FP = False Positive and FN = False Negative

$$\text{F1 score} = 2 \text{ x } \frac{\text{Precision x Recall}}{Precision + Recall}$$

The table below shows comparative performance evaluation values of this model using the confusion matrix conducted in 2021 compared to the latest 2022 results for the As and Bs models:

Table 1: Model As performance score for 2021

As 2021	precision	recall	F1-score	n
Eczema	0.70	0.65	0.68	40
Fungal infection	0.75	0.30	0.43	10
Others	0.87	0.94	0.90	114
Scabie	0.50	0.52	0.67	1
Accuracy			0.83	167
Weighted average	0.82	0.83	0.81	167

Table 2: Model As performance score for 2022

As 2022	precision	recall	F1-score	n
Eczema	0.92	0.93	0.93	2429
Fungal infection	0.60	0.09	0.16	32
Impetigo	0.85	0.81	0.83	36
Insect bite	0.55	0.81	0.66	26
Others	0.80	0.81	0.81	887
Scabie	0.76	0.52	0.62	25
Accuracy			0.89	3435

Weighted average	0.88	0.89	0.88	3435

These metrics indicate a positive evolution in the model's performance compared to the number of cases collected. However, eczema remains the only pathology that is easiest to detect at present. The table below shows the evaluation for eczema, using the Bs model, comparing the scores obtained in 2021 and during the first six months of this year:

Table 3: Model Bs performance score for 2021

Bs 2021	precision	recall	F1-score	n
Eczema	0.62	0.73	0.67	33
Others	0.93	0.90	0.91	143
Accuracy			0.86	176
Weighted average	0.87	0.86	0.87	176

Table 4: Model Bs performance score for 2022

Bs 2022	precision	recall	F1-score	n
Eczema	0.92	0.92	0.92	2391
Others	0.82	0.81	0.81	1046
Accuracy			0.89	3437
Weighted average	0.89	0.89	0.89	3437

The difference is clearly visible between 2021 and 2022. While in 2021 there was only one collection site in Antananarivo, in 2022 there were four sites. The number of collected and validated cases by dermatologists increased from 33 to 2391 with an accuracy of 62% to 92%. In parallel, another model has been trained using data collected in Africa, mainly in Madagascar, Tanzania, and Guinea Conakry. This model, as before, (Aa) evaluates performance scores for the five studied pathologies, excluding scabies, impetigo, and insect bites, and (Ba) for eczema, which remains the easiest class to detect. In 2022, the results obtained again showed positive improvement.

Table 5: African Model Aa performance score for 2022

Aa 2022	precision	recall	F1-score	n
Eczema	0.70	0.65	0.68	40
Fungal infection	0.75	0.30	0.43	10
Others	0.87	0.94	0.90	115
Scabie	0.50	1.00	0.67	15

Accuracy			0.83	180
Weighted average	0.82	0.83	0.81	180

Table 6: African Model Ba performance score for 2022

Ba 2022	precision	recall	F1-score	n
Eczema	0.62	0.73	0.67	33
Others	0.93	0.90	0.91	143
Accuracy			0.86	176
Weighted average	0.87	0.86	0.87	176

Considering the data imbalance, the results for As and Bs are better than those for Aa and Ba. However, the initial results are promising and are expected to improve in the coming months with more data forthcoming.

4- Discussions

This preliminary result will evolve in the future based on new data collected. We trained on 2429 photos for eczema and found an accuracy of 92%. Comparing this performance to that of other similar studies, our results seem consistent with the existing data volume. Rasheed A et al. (2022) developed a dermatological photo recognition algorithm using Deep Learning and achieved an accuracy of 88.29% for 2039 labeled eczema photos, a similar approach to our image classification system. It is important to mention that potential regression of scores in the future does not mean that the model is less effective. In fact, the current score represents the AI's ability to correctly classify on an unknown set of collected data. By adding more data, it is much more probable for the model to achieve even higher performance scores (Karthik et al. 2022).

The scores obtained here reflect the best results for the collected data and serve as a relevant indicator of possible future outcomes in a clinical setting. A comparative analysis of this prediction with the diagnosis made by an experienced dermatologist, as was done by Zhu C-Y et al. (2021) in a clinical study, will evaluate new model confidence scores (Zhu et al. 2021) in real conditions.

Several researchers have developed an algorithm for the recognition of dermatological lesions using a convolutional neural network such as Yang Y et al. (2021) (Yang et al. 2021) for psoriasis, Monnier J et al. (2021) (Monnier et al. 2021), Delyon J et al. (2021) (Delyon et al. 2021), and Zhang L et al. (2020) (Zhang et al. 2020) for the automatic detection of dermal melanoma, and others such as Rasheed A et al. (2022) (Rasheed et al. 2022), Dautović A et al. (2022) (Dautović et al. 2022) for eczema and atopic dermatitis, as well as other studies focused on the development of algorithms to recognize several skin diseases (Young et al. 2020). Our study, based on these same methods, extends to the morphological and clinical analysis of each pathology across all phototypes from 1 to 6: from white skin to black skin.

This algorithm has been developed in the context of initial and continuous medical education in dermatology. Although it is an intelligent diagnostic aid system, the AI engine does not automatically provide answers to questions; it requires the user to do so. The machine is used to assess human knowledge based on its own. With new data, students and/or physicians will have a training tool at their disposal to familiarize themselves with dermatological pathologies without the presence of a dermatologist to evaluate their response. "The machine learns to teach us."

As limiting factors, the insufficient number of collected cases for some of the relevant pathologies such as scabies, impetigo, insect bites, and fungal infections resulted in an imbalance in the classification of photos in the dataset. This insufficiency did not allow us to obtain significant results for these pathologies. In a brainstorming workshop, we will address the subject to define a new collection strategy to accelerate photo acquisition. At the moment, we only have the Befelatanana University Hospital, the Serenity Clinic, and the Establishment of Public Health Care (ESSPA) in Analakely for Antananarivo, the Reference Hospital Center at the District level in Antsirabe, and the University Hospital in Androva Mahajanga as data collection sites in

Madagascar. The connection speed outside Antananarivo also slowed down the file transfer process to the central server.

5- Conclusion

As this is an ongoing study, we are still evaluating the results of model training to improve existing outcomes following the methods we used last year, and we will be able to report the results in the coming months. The objective is to set up a pedagogical self-assessment system to improve access to care in regions or areas without dermatologists so that physicians are not obliged to leave their post for continuous training in the capital. As a decision support system, the machine will not provide answers to questions ; it will be up to the user to do so. The machine will be used to assess human knowledge based on its own.

Since this year, the Madagascar technical team has worked with the Swiss team to seek to establish a new learning model for phototypes 3, 4, and 5 in order to subsequently conduct a comparative study to finalize algorithm development (Trakatelli et al. 2017). It is important to note that the literature shows very little work on the comparative aspect of lesion recognition with respect to different types of skin pigmentation (Adamson and Smith 2018 ; Roberts 2009), except for the use of the CycleGAN approach for data augmentation (Han et al. 2020) (Andrade et al. 2020).

The challenge of this study is to contribute to the mission of assistance and continuous education in Dermatology with a fully dematerialized approach, avoiding any travel of physicians: a global contribution to the preservation of climate and the environment (Kim and Rohmer 2012) (Somemura 2010) and socio-economic development for developing countries. Its particularity mainly lies in lesion recognition with respect to all phototypes. Its utility will not be limited either in a socio-economic or racial context. In Madagascar, for example, there are possibilities to receive patients of phototypes 1, 2, and 6. Similarly, in Europe, Asia, or America, immigration is everywhere in the world, so the presence of all phototypes in consultations is therefore always possible. Model training on dark skin in the context of this study is thus only a subset of the overall approach adopted by the project as a vector for algorithm development for the final product.

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7- References

T. Panch, P. Szolovits, R. Atun. "Artificial intelligence, machine learning and health systems," J. Glob. Health 8 (2022), 020303.

P. Callier, O. Sandel, "De l’intelligence artificielle à son application en médecine," Actualités Pharmaceutiques 60 (2021), 18 20.

D. Gruson. Le temps est compté. Soins, 64(2019), 29–57. Doi:10.1016/j.soin.2019.06.004

K. Marquet, F. Berthoud, J. Combaz, "Introduction aux impacts environnementaux du numérique," 1024 (2019), 85 97.

L. Zhang, H.J. Gao, J. Zhang, B. Badami. "Optimization of the Convolutional Neural Networks for Automatic Detection of Skin Cancer," Open Med (Wars) 15 (2020), 27 37.

T. Shanthi, R.S. Sabeenian, R. Anand. "Automatic diagnosis of skin diseases using convolution neural network," Microprocessors Microsystems 76 (2020), 103074.

N. Hameed, A.M. Shabut, M.K. Ghosh, M.A. Hossain. "Multi-class multi-level classification algorithm for skin lesions classification using machine learning techniques," Expert Syst. Appl. 141 (2020), 112961.

C-Y. Zhu, Y-K. Wang, H-P. Chen, K-L. Gao, C. Shu, J-C. Wang, et al. "A Deep Learning Based Framework for Diagnosing Multiple Skin Diseases in a Clinical Environment," Front Med (Lausanne) 8 (2021), 626369.

S. Chan, V. Reddy, B. Myers, Q. Thibodeaux, N. Brownstone, W. Liao. "Machine Learning in Dermatology: Current Applications, Opportunities, and Limitations," Dermatol Ther (Heidelb) 10 (2020), 365 86.

R.R. Barbieri, Y. Xu, L. Setian, P.T. Souza-Santos, A. Trivedi, J. Cristofono, et al. "Reimagining leprosy elimination with AI analysis of a combination of skin lesion images with demographic and clinical data," Lancet Reg. Health - Americas 9 (2022), 100192.

D. Hendrycks, K. Gimpel. "Gaussian Error Linear Units (GELUs)," [Internet] arXiv; 2023. Available on: http://arxiv.org/abs/1606.08415 Last visit: 2024/20/01

B. Wu, C. Xu, X. Dai, A. Wan, P. Zhang, Z. Yan, et al. "Visual Transformers: Token-based Image Representation and Processing for Computer Vision," [Internet] arXiv; 2020. Available from: http://arxiv.org/abs/2006.03677

C. Hsu, P. Gottfrois, Y. Xiao, D. Mavura, H. Hassan, F. Rapelanoro Rabenja., et al. "Artificial intelligence (AI) in dermatology: An application in sub-Saharan Africa," J. Am. Acad. Dermatol. 85 (2021), AB183.

R. Karthik., T.S. Vaichole, S.K. Kulkarni, O. Yadav, F. Khan. "Eff2Net: An efficient channel attention-based convolutional neural network for skin disease classification," Biomed. Signal Process. Control 73 (2022), 103406.

X. Zhang, K. Shu, S. Rajkumar, V. Sivakumar. "Research on deep integration of application of artificial intelligence in environmental monitoring system and real economy," Environ. Impact Assess. Rev. 86 (2021), 106499.

Y. Yang, J. Wang, F. Xie, J. Liu, C. Shu, Y. Wang, et al. "A convolutional neural network trained with dermoscopic images of psoriasis performed on par with 230 dermatologists," Comput. Biol. Med. 139 (2021), 104924.

J. Monnier, A.C.F. Gouabou, M. Serdi, R. Iguernaissi, C. Gaudy-Marqueste, J-L. Damoiseaux, et al. "Détection automatique du mélanome : comparaison d'un algorithme fondé sur la caractérisation de l'aspect désordonné de lésions mélanocytaires mimant la pratique des dermatologues, avec une approche par CNN (Convolutional Neural Network)," Ann. Dermatol. Venereol. FMC 1 (2021), A135.

J. Delyon, B. Schmauch, Y. Jacob, M. Galtier, A. Maire, C. Velter, et al. "Développement d'un algorithme d'intelligence artificielle pour le diagnostic de mélanome à partir d'une banque d'images issues de la pratique courante," Ann. Dermatol. Venereol. FMC 1 (2021), A138 9.

A. Rasheed, I. Umar, S.H. Shirazi, Z. Khan, S. Nawaz, M. Shahzad. "Automatic eczema classification in clinical images based on hybrid deep neural network," Comput. Biol. Med. 147 (2022), 105807.

A. Dautović, B. Đondraš, F. Dervišbegović, A. Smajović, E. Bečić, L.S. Bećirović, et al. "Diagnosis of Atopic dermatitis Using Artificial Neural Network," IFAC-PapersOnLine 55 (2022), 51 5.

A.T. Young, M. Xiong, J. Pfau, M.J. Keiser, M.L. Wei. "Artificial Intelligence in Dermatology: A Primer," J. Invest. Dermatol. 140 (2020), 1504 12.

M. Trakatelli., M. Bylaite-Bucinskiene., O. Correia, A. Cozzio., E. De Vries, L. Medenica., et al. "Clinical assessment of skin phototypes: watch your words!" Eur. J. Dermatol. 27 (2017), 615–9.

A.S. Adamson, A. Smith. "Machine Learning and Health Care Disparities in Dermatology," JAMA Dermatol. (2018).

W.E. Roberts. "Skin type classification systems old and new," Dermatol. Clin. 27 (2009), 529–33, viii.

S.S. Han, et al. "Augmented Intelligence Dermatology: Deep Neural Networks Empower Medical Professionals in Diagnosing Skin Cancer and Predicting Treatment Options for 134 Skin Disorders," J. Invest. Dermatol. 140 (2020), 1753–61.

C. Andrade, L.F. Teixeira, M.J.M. Vasconcelos, L. Rosado. "Data Augmentation Using Adversarial Image-to-Image Translation for the Segmentation of Mobile-Acquired Dermatological Images," J. Imaging 7 (2020), 2.

J. Kim, S. Rohmer. "Electronic billing vs. paper billing: Dematerialization, energy consumption and environmental impacts," Electronics Goes Green 2012+ (2012), 1–4.

Y. Somemura. "Key Roles of Green Technology for Access Network Systems," Opt. Fiber Commun. Conf. [Internet] San Diego, California: OSA; 2010. Available from https://opg.optica.org/abstract.cfm?URI=OFC-2010-OTuO6

8- Tables

9- Figures

Figure 1: Capturing photographs of skin lesions at a focal distance of 25cm and 10cm
Figure 2: Image segmentation process of dermatological elementary lesions