Deep learning based chronic kidney disease detection through iris

H A U Rehman1*, C Y Lin1 and S F Su2

1Department of Mechanical Engineering, National Taiwan University of Science & Technology, No 43 Section 4, Keelung Road, Da’an District, Taipei, 10607, Taiwan
2Department of Electrical Engineering, National Taiwan University of Science & Technology, No 43 Section 4, Keelung Road, Da’an District, Taipei, 10607, Taiwan
*Email: d10603813@mail.ntust.edu.tw

Abstract. Kidney is an important organ in human body as it maintains the nutrients and fluid balance in our body. It is extremely beneficial if its dysfunctionality is diagnosed at an early stage. Iridology provides a pathway to examine the kidney disease through iris images. Therefore, in this work we proposed the Iris-based Kidney Disease Identification System (IKDIS). The IKDIS would aid in identifying abnormalities through iris images an input which would be followed by application of deep neural network model for assessment. This type of diagnostic system without involving any instruments for assessment of human body organs is much popular these days. The data of 49 patients gives promising results of IKDIS, achieving overall accuracy of 86.9% during the experiment.

1. Introduction
In the recent years, the combination of image processing and machine learning has been widely used to solve real-life problems in which medical image analysis and surveillance are on the top of the list [1], [2], [3]. From the last two decades, alternative medicine and early diagnosis are the main demands in health care system to provide quality health services and also to save from many complications [4]. Iris diagnosis (iridology) has been extensively used for examining the patient’s health. The Iris of the human eye plays a pivotal role in observing the health condition while reviewing the possible disturbances of the internal body organs[5].

Figure 1 shows the different regions that are associated with various human body organs[6]. A mark, pattern or spot may appear in result of any weakness or damage of the organ[7]. These iris-patterns can help us to identify the corresponding/affected organ[8]. Figure 2 shows the seven zones in the iris around the pupil [8], [9]. In case of unhealthy stomach, the changes may appear near the pupil in the iris. On the other hand, unhealthy kidneys may be detected through the changes at the bottom edge of iris.

In the human urinary system, kidneys play an important role to eliminate the waste products from human body. Any disorder in the kidneys may lead to diabetes, hypertension, urological, acute renal function and cardiovascular issues as some of major fatal problems[10],[11].

In this proposed work, an Iris-based Kidney Disease Identification System (IKDIS) is developed. The IKDIS will perform early assessment of kidney disorder based on iridology chart and artificial intelligence (AI) algorithm. The AI algorithm will classify the subject body either healthy or unhealthy.
The motivation of this work is to provide useful online practical system to determine results in cost-effective, quick and painless way.

![Figure 1. Iridology chart [19].](image1)

![Figure 2. Seven zone of Iris.](image2)

2. Related works

Several research works have been conducted on human eye to identify and diagnose various diseases which is known as iridology. Hussain et al [6] proposed a unique approach, which consist of iris image collection, pre-processing, segmentation, feature extraction and a neuro-fuzzy interface system (ANFIS) to identify and distinguish between the normal or chronic kidney diseases. They examined total of 340 patients which were classified into 168 patients with healthy kidneys and 172 patients suffering from kidney disease. The proposed system showed overall 82% accuracy for normal and kidney failure individuals respectively.

Sara Amerifar et al [3] have done research work on CASIA iris image database to diagnose chronic kidney disease. They used Hussain et al [6] analysis for geometrical enhancement and CHT to detect circular shape. Their results indicated 82% and 93% accuracy for Chronic Renal Failure (CRF) and non-CRF subjects respectively.

Agus Prayitno et al [12] implemented their research on kidney complications mainly caused by diabetes. Iris Region of Interest (ROI) images were taken from 47 patients with the help of Dino-Lite Ver. 2.2. They used colour constancy and independent component analysis to analyse the broken tissue in the ROI iris images. 76% accuracy indicated that 31 individuals among 47 patients have kidney complications.

Adhi et al [13] diagnosed the last stage of kidney CRF with the implementation of machine learning. Hemodialysis patients and healthy persons were classified based on broken tissues in iris. To examine the broken tissues, the authors used watershed method for feature segmentation. Support Vector Machine classification showed overall 87.5% accuracy of the experiment.

Several other research has been done using iridology. For example, Rossi Erwin et al [14] worked on digestive problem, Jamal et al [15] detected diabetes, Samant and Agarwal [9] also diagnosed diabetes,
Anna et al [16] found lung abnormalities, Hernandez et al [17] worked on Alzheimer’s disease, and last but not least, Permatasari et al [18] presented a method to evaluate heart condition.

3. Iris based kidney diagnostic system

3.1. Kidney pathology
The assessment of various disease pattern and its features can be easily determined by the help of iridology chart shown in figure 1. The region of interest (ROI) for kidney disease in right and left eye are at position 5.35–5.95 (252–268) and 6.05–6.60 (272–288). A long solid black line, one or more and large or small open lesion and change in colour of the iris tissues are the main symptoms of the kidney disease. Figure 3 shows the after effect of the kidney disease in the iris images.

![Figure 3](image)

**Figure 3.** Marks and pattern showing kidney problem in (a) right eyes (b) left eyes [19].

3.2. Experimental setup description
The hardware setup used for this research is based on Core i7-7700HQ CPU @ 2.80 GHZ, with 512 GB SSD, 2 TB HDD, 32GB RAM and Nvidia 6 GB GTX1080 GPU. The IKDIS system uses Linux based operating system where it is easy to program artificial intelligence frameworks like Tensorflow, KERAS etc.

4. Results and discussions

4.1. Dataset
The Iris dataset were taken from the Surgical Section I, Bahawal Victoria Hospital, Pakistan. The dataset is fully verified and endorsed by famous ophthalmologist working in the same hospital after labelling work. The Iris dataset consisted of total 49 patients suffering with chronic kidney disease.

4.2. Performance analysis and architecture of proposed network
The experimental process of the proposed research used a Convolutional Neural Network (CNN) model implemented from scratch to introduce the transfer learning technique with max-pooling function. To train CNN model, various libraries were used. Among these libraries, KERAS was widely used because of its user friendly environment such as adding, dropping layers and max-pooling function in CNN.

The architecture of proposed CNN is consisted of total of five layers in which three are convolution layers and remaining two are dense layers. The detailed description of these layers are given below.

L1: Layer one of the CNN model contains 24 filters with a 3*3 strided max-pooling function and (224x224x3) input size.

L2: The second layer of Model contains 36 filters with a 2*2 strided max-pooling function with same input size (224x224x3).

L3: Layer three of the model contains 48 filters without involving max-pooling function with input size (224x224x3).

L4: Fourth layer of the Model is first dense layer with 60 hidden units. To reduce the overfitting problem, dropout rate 0.5 was used.
Layer five is the second dense layer which is also the last layer with softmax activation function. The remaining important parameters are the usage of Rectified Linear Unit (ReLU) as an activation function in the first four layers whereas Softmax was used for the last layer. Fixed learning rate 0.01 was used with the Stochastics Gradient Descent (SGD) optimizer for the training of the model. Figure 4 illustrates the validation accuracy versus training accuracy. To analyse the performance of the proposed model, CNN trained on iris images and showed 86.9% accuracy.

Figure 4. Proposed CNN model performance with max-pooling function.

4.3. Health assessment demo
The kidney health assessment demo is presented in this section. At the first step, the system taken iris image with the help of handheld iris camera. Then, the system applied deep learning algorithm to find any marks, line or pattern in the ROI region. At the final step the system determines the result and provide the health notice shown in Figure 5.

Figure 5. Health assessment system graphical user interface (GUI)
(a) main screen (b) image obtained (c) health result

4.4. Comparison with existing result
Table 1 showed the comparison of the proposed study with others existing studies.
5. Conclusion
In this study Iris-based Kidney Disease Identification System is proposed to diagnose dysfunctional kidneys based on machine learning algorithm and iridology. This type of alternative medical diagnostic system recognizes discrepancies in iris texture and aids the medical staff to identify the disease at early stages. In future, new CNN architecture will hopefully be developed and applied to detect kidney problem more efficiently and with high accuracy.

References
[1] Dehshibi M M and Bastanfard A 2010 A new algorithm for age recognition from facial images Signal Processing 90 pp 2431-2444
[2] Dehshibi M M, Fazlali M and Shanbehzadeh J 2014 Linear principal transformation: Toward locating features in N-dimensional image space Multimed. Tools Appl. 72 pp 2249–2273
[3] Amerifar S, Targhi A T and Dehshibi M M 2016 Iris the picture of health: Towards medical diagnosis of diseases based on iris pattern The 10th International Conference on Digital Information Management, ICDIM 2015 (Institute of Electrical and Electronics Engineers Inc.) pp 120–3
[4] Shon H S, Batbaatar E, Kim K O, Cha E J and KimK-A 2020 Classification of Kidney Cancer Data Using Cost-Sensitive Hybrid Deep Learning Approach Symmetry (Basel). 12 p 154
[5] Lodin A and Demea S 2009 Design of an iris-based medical diagnosis system 2009 International Symposium on Signals, Circuits and Systems, ISSCS 2009
[6] Hussein S E, Hassan O A and Granat M H 2013 Assessment of the potential iridology for diagnosing kidney disease using wavelet analysis and neural networks Biomed. Signal Process. Control 8 pp 534-541
[7] Hussain T, Haider A, Muhammad A M, Agha A, Khan B, Rashid F, Raza M S, Din M, Khan M, Ullah S, Ahmed A T and Ayguade E 2019 An iris based lungs pre-diagnostic system 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies, iCoMET 2019 (Institute of Electrical and Electronics Engineers Inc.)
[8] Li Y H, Aslam M S, Yang K L, Kao C A and Teng SY 2020 Classification of Body Constitution Based on TCM Philosophy and Deep Learning Symmetry (Basel). 12 p 803
[9] Samant P and Agarwal R 2018 Machine learning techniques for medical diagnosis of diabetes using iris images Comput. Methods Programs Biomed. 157 pp 121-128
[10] Romagnani P, Remuzzi G, Glassock R, Levin A, Jager K J, Tonelli M, Massy Z, Wanner C and Anders H J 2017 Chronic kidney disease Nat. Rev. Dis. Prim. 3 pp 1-24
[11] Levin A, Tonelli M, Bonventre J, Coresh J, Donner J A, Fogo A B, Fox C S, GansveoortR T, HeerspinkH J L, Jardine M, Kasiske B, Köttingen A, Kretzler M, Levey A S, Luycx V A, Mehta R, Moe O, Obrador G, Pannu N, Parikh C R, Perkovic V, Pollock C, Stenvinkel P, TuttleK R, Wheeler D C, EckardtK U, AduD, Agarwal S K, Alrukhaimi M, Anders H J, Ashuntantang G, Basnet S, Bello A K, Chailimpamontree W, Correa-Rotter R, Craig J, Douthat W G, Feldman H I, Ganjii M R, Garcia-Garcia G, Gharbi M B, Harris D C, Jha V, Johnson D W, Kazancioglu R, Langham R, Liu Z H, Massy Z A, Nangaku M, NelsonR G, O’DonoghueD, Okpechil, Pecoits-Filho R, PoweN R, Remuzzi G, Roberts C, Rossert J, SolaL, Stengel B, ME K S, Suzuki Y, Tanaka T, Tatiyanupanwong S, Thomas B, Uhlig K, Walker R, White S L, Wieck A and Yang C W 2017 Global kidney health 2017 and beyond: a roadmap for closing gaps in care, research, and policy Lancet 390 pp1888-1917

Table 1. Comparison summary.

| Author               | Method Used                      | Accuracy(%) |
|----------------------|----------------------------------|-------------|
| Hussein et al [6]    | 2-D Gabor Transform and ANFIS    | 82          |
| S. Amerifar et al [3] | Circular Hough Transform Algorithm | 82          |
| Prayitno et al [12]  | Iris Localization                | 76          |
| **Proposed Method**  |                                  | 86.9        |
[12] Prayitno A, Wibawa A D and Purnomo M H 2017 Early detection study of Kidney Organ Complication caused by Diabetes Mellitus using iris image color constancy Proceedings of 2016 International Conference on Information and Communication Technology and Systems, ICTS 2016 (Institute of Electrical and Electronics Engineers Inc.) pp 146-149

[13] Sitorus M A R, Purnomo M H and Wibawa A D 2016 Iris image analysis of patient Chronic Renal Failure (CRF) using watershed algorithm Proceedings - 2015 4th International Conference on Instrumentation, Communications, Information Technology and Biomedical Engineering, ICICI-BME 2015 (Institute of Electrical and Electronics Engineers Inc.) pp 54–8

[14] Passarella R, Erwin E, Fachrurozi M and Sutarno S 2013 Development of Iridology System Database for Colon Disorders Identification using Image Processing Indian J. Bioinforma. Biotechnol. 2 pp 100-103

[15] Banzi J F and Xue Z 2015 An Automated Tool for Non-contact, Real Time Early Detection of Diabetes by Computer Vision Int. J. Mach. Learn. Comput. 5 pp 225-229

[16] Triwijayanti K.A, Suwastio H and Damayanti R 2016 Lung Disorders Detection Based on Irises Image Using Computational Intelligent Art TEKTRIKA - J. Penelit. dan Pengemb. Telekomun. Kendali, Komputer, Elektr. dan Elektron. 8 pp 59-66

[17] Hernandez F, Vega R, Tapia F, Morocho D and Fuertes W 2018 Early detection of Alzheimer’s using digital image processing through iridology, an alternative method Iberian Conference on Information Systems and Technologies, CISTI vol 2018-June (IEEE Computer Society) pp 1-7

[18] Permatasari L I, Novianty A and Purboyo T W 2017 Heart disorder detection based on computerized iridology using support vector machine ICCEREC 2016 - International Conference on Control, Electronics, Renewable Energy, and Communications 2016, Conference Proceedings (Institute of Electrical and Electronics Engineers Inc.) pp 157-161

[19] Muzamil S, Hussain T, Haider A, Waraich U, Ashiq U, and Ayguadé E 2020 An Intelligent Iris Based Chronic Kidney Identification System Symmetry. 12(12) pp 2066-2076