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關鍵詞　Chronic Kidney Disease (CKD), retinal image, Artificial Intelligence, Deep Learning

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A PROJECT PREPORT ON

"KidneyLifePlus+ : Retinal Imaging Analysis for Kidney Disease Risk Assessment"

Submitted by:

Chananphat Tacharoenmuang

Payuphat Boontaokaew

Pimlada Patiphatpatawee

A Project Report Submitted for the partial fulfillment of the requirement of Taiwan International Science Fair 2025 supervised by Ministry of Education, Taiwan and organized by National Taiwan Science Education Center

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Project name: KidneyLifePlus+ : Retinal Imaging Analysis for Kidney Disease Risk Assessment

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Abstract

Chronic kidney disease (CKD) represents a significant public health challenge, often referred to as a "silent disease" due to its asymptomatic progression during early stages (1–2). Consequently, most diagnoses occur during advanced stages (3 and beyond), where treatment options are more complex and outcomes are less favorable. Globally, CKD affects over 850 million individuals, with 434.3 million cases in Asia alone. Despite its prevalence, early-stage awareness remains alarmingly low, with only 5% of affected individuals aware of their condition. Existing screening methods are predominantly hospital-based, expensive, and time-intensive, limiting their accessibility, particularly in resource-constrained settings. This underscores an urgent need for more accessible and efficient diagnostic tools to enable early intervention.

In response to this critical problem, we developed KidneyLifePlus+, an AI-powered platform that leverages advanced machine learning models, including U-net, ResNet-50, and YOLO v8, to analyze retinal images for early CKD detection. These models are integrated to ensure high screening accuracy by identifying subtle biomarkers indicative of CKD progression. Complementing the software, we designed proprietary hardware capable of capturing high-resolution retinal images, delivering performance comparable to hospital-grade equipment. By ensuring affordability and ease of use, the system extends screening capabilities beyond clinical environments, making it suitable for deployment in community healthcare settings.

KidneyLifePlus+ addresses key limitations of traditional methods by offering a rapid, cost-effective, and highly accurate diagnostic solution. The platform's potential to enhance early detection rates could significantly improve clinical outcomes and quality of life for CKD patients. Furthermore, this innovation contributes to global efforts to reduce the burden of CKD by promoting equitable access to diagnostic services, particularly in underserved regions.

Keyword: Chronic Kidney Disease (CKD), retinal image, Artificial Intelligence, Deep Learning

Acknowledgement

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We are profoundly indebted to our advisor, assistant advisor Krittipong Wachirangkul, whose expertise, guidance, and encouragement have been indispensable throughout this process. Their unwavering support and insightful suggestions have greatly enhanced the quality of this work and deepened our understanding of the subject matter.

Our deepest gratitude extends to the Technology Excellence Program faculty members, friends, and family for fostering a supportive and stimulating environment. The opportunities and resources provided by The Prince Royal’s College and its dedicated faculty have been fundamental in nurturing our academic growth and research capabilities. This research would not have been possible without the collective support of our school, advisor, and the broader community, whose commitment to education and innovation has been the cornerstone of this achievement.

Project Development Team

KidneyLifePlus+: Retinal Imaging Analysis

for Kidney Disease Risk Assessment

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Introduction

Chronic Kidney Disease (CKD) can arise from behavioral and hereditary factors that adversely impact kidney health. Behavioral contributors include the unsupervised use of over-the-counter medications to alleviate disease symptoms, excessive consumption of high-salt foods, and inadequate nutritional intake. These practices strain the kidneys, compelling them to work harder than usual. Over time, this increased workload can impair the kidneys' ability to effectively filter blood, leading to a decline in their filtering capacity and the progression of CKD. Additionally, hereditary factors may predispose individuals to kidney dysfunction, further exacerbating the risk of developing chronic kidney conditions (National Kidney Foundation, 2016).

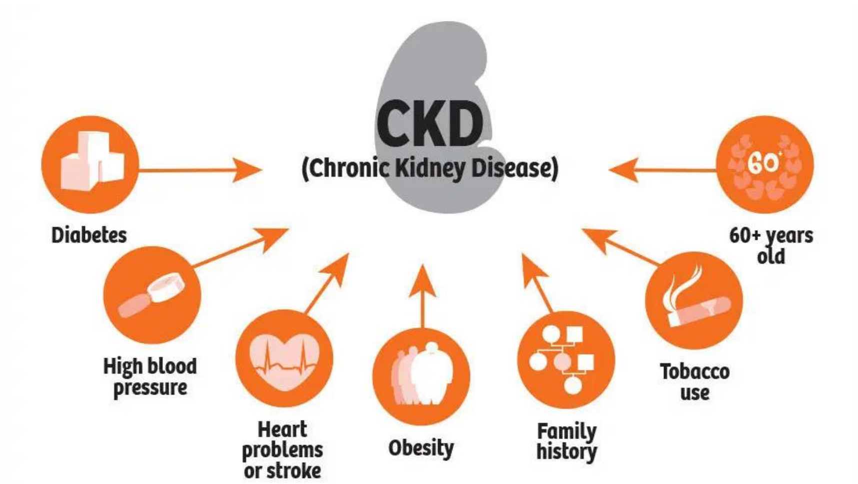


Figure 1 shows causes of Chronic Kidney Disease

From (https://www.siemens-healthineers.com/laboratory-diagnostics/assays-by-diseases-conditions/kidney-disease/about-kidney-disease)

According to the International Society of Nephrology (2018), these factors affect over 850 million people globally, and had an increased death rate of 41.5%. In the Asian region alone, 434.3 million individuals are affected by chronic kidney disease (CKD). Furthermore, most Asian countries have documented an increase of more than 100% in the absolute count of CKD incident cases, deaths, prevalence, and disability-adjusted life years (DALYs). Most importantly, 9 out of 10 people with chronic kidney disease are unaware they have the condition (National Institute of Diabetes and Digestive and Kidney Disease, 2023). This lack of awareness contributes to a staggering toll, with 5 to 11 million people losing their lives to chronic kidney disease each year (International Society of Nephrology, 2024).

Chronic kidney disease (CKD) progresses through five stages, each with distinct symptoms:

- **Stage 1:** Protein in the urine (proteinuria) with normal kidney function; low risk.
- **Stage 2:** Mild decline in filtration rate; early signs like fatigue and changes in urination may appear.
- **Stage 3:** Moderate decline in kidney function with swelling, fatigue, and increased risk of heart disease.
- **Stage 4:** Severe decline in function; symptoms include appetite loss and swelling. Kidney replacement discussions begin.
- **Stage 5:** Complete kidney failure; symptoms include nausea, fatigue, and fluid retention. Dialysis or transplantation is required.

According to the National Kidney Foundation (NKF), stage 3 is often when chronic kidney disease (CKD) is first diagnosed, as an eGFR blood test alone can reliably detect kidney function decline. At this stage, patients may begin to exhibit symptoms such as fatigue, swelling, or changes in urination, and develop complications like heart disease, diabetes, or high blood pressure. In Asia, CKD-related complications contribute significantly to mortality, accounting for an estimated 9.8 million deaths across the region.

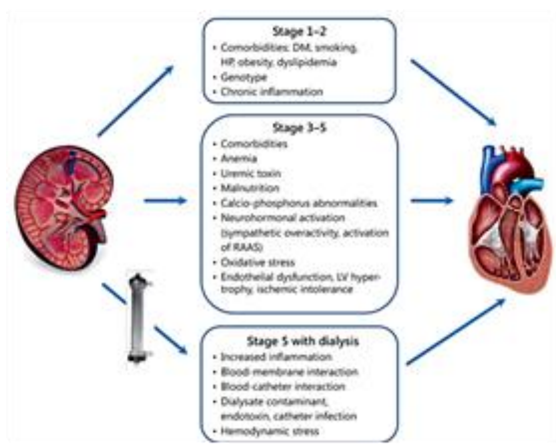


Figure 2 shows complications arising from different stages of kidney disease.

From (Cardiorenal Syndrome Type 4: A Review - Scientific Figure on ResearchGate)

Therefore, **screening for chronic kidney disease is crucial for early detection and timely treatment**, helping to reduce future mortality rates. However, challenges remain, particularly the high costs associated with hospital-based screening, which limit accessibility for many patients. The cost of a health check-up program to screen for kidney disease can be as high as 4,300 baht (123.92 USD) per session (Bangkok Hospital, 2024). As a result, individuals at risk of kidney disease, especially those with low incomes, often lack access to quality screening due to the high cost of kidney examination equipment. The screening process requires at least one hour, including diagnostic radiology (CT scan) and secretion analysis. Additionally, preparing for a CT scan involves fasting for 8 to 12 hours beforehand.

To address this issue, the development team designed an innovative self-screening solution for chronic kidney disease using retinal imaging. Integrated with advanced AI technology and algorithms, this approach ensures accessibility, affordability, and ease of use. A user-friendly application, paired with specialized hardware for independent retinal imaging, providing a comprehensive and efficient tools for kidney disease screening called "KidneyLifePlus+ : Retinal Imaging Analysis for Kidney Disease Risk Assessment"

The solution incorporates a specialized artificial intelligence algorithm, **NephroNet**, designed to screen for chronic kidney disease using retinal images. NephroNet integrates multiple AI models to enhance analysis accuracy, delivering reliable results with exceptional precision. This innovative approach enables convenient, on-the-go screening through the **KidneyLifePlus+** application, ensuring accessibility anytime and anywhere.

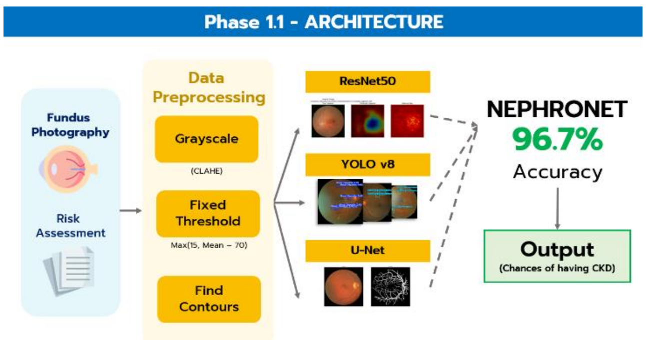


Figure 3 displays the Nephronet architecture

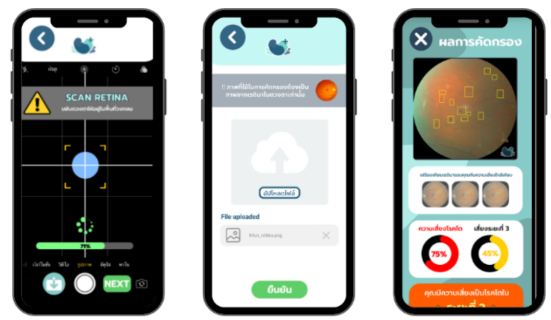


Figure 4 demonstrates KidneyLifeplus+ Application

Additionally, the development team created specialized hardware, known as the RetinaScope, enabling users to capture their own retinal images. This device is designed to seamlessly integrate with the application for efficient and convenient use.

Figure 5 displays the Hardware "Retina Scope"

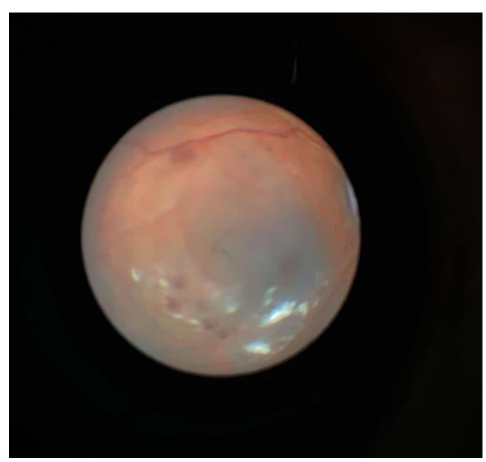


Figure 6 demonstrates retina image using the hardware during experiments conducted with simulated eye models.

Objective

1. Develop a smartphone-based retinal imaging tool with AI for initial screening to assess kidney disease risk at different stages.
2. Provide fast and affordable screening to enable early detection, particularly for low-income individuals, and help reduce kidney disease-related deaths.

Problem and benefits

Problems

1. Chronic kidney disease (CKD) impacts more than 850 million people worldwide, with 434.3 million cases reported in Asia. Alarmingly, just 5% of affected individuals recognize their condition in its early stages.
2. The global mortality from all kidney diseases likely ranges **between 5 million and 11 million per year**
3. Current screening methods are costly, time-consuming, and inaccessible outside hospital settings. Make a lot of people knowing late.

Benefits

Patients

1. Patients can self-monitor their kidney health through a streamlined, three-step process: retinal scanning, image upload to the software, and automated result generation. This user-friendly approach eliminates the need for expert guidance, providing results within 7–8 minutes. It facilitates early detection of chronic kidney disease (CKD), empowering patients with timely information about their health status.

2. Early detection enables patients to undertake preventive measures such as medication, dietary management, and regular exercise, potentially delaying or avoiding the need for dialysis in advanced stages of CKD.

Healthcare Professionals

1. The platform significantly reduces the workload and time required for reading and analyzing early-stage CKD cases, allowing healthcare professionals to focus on critical and complex cases. Furthermore, it broadens access to CKD screening, supporting timely and effective treatment for patients.

2. Clinicians and specialists in remote areas can leverage the platform to facilitate proactive health screening programs efficiently. By utilizing KidneyLifePlus+ tools—including a fundus camera and dedicated application—healthcare providers can extend CKD screening services to underserved communities.

Environmental Impact

1. The platform contributes to environmental sustainability by minimizing medical waste associated with traditional CKD screening procedures. Additionally, it reduces potential waste generated by dialysis treatments in advanced CKD stages through earlier detection and intervention.

Hypothesis

1. The retinal imaging tool will be effective and capable of observing the details within the user's retina comparable to the retinal imaging tools used in hospitals.
2. The convolutional neural network-based artificial intelligence system will be able to classify the risk of kidney disease at different stages from retinal images.
3. The segment detection-based artificial intelligence system will be able to detect crystal deposits in the eye and identify spots that occur on the retina of individuals with kidney disease.

Scope of study

1. The user's mobile phone must have internet access to connect with the artificial intelligence system.
2. Users must have access to the Google Play Store or Apple App Store on their mobile device to download the **KidneyLifePlus+** application.
3. Patients must have functional vision and no significant retinal injuries or wounds to ensure accurate screening results.

Related Documents

Chronic Kidney Screening (CKD)

Phyathai Hospital (2023) has stated that chronic kidney disease is a condition characterized by the gradual and progressive loss of kidney function. This decline reduces the kidneys' ability to filter waste and maintain essential bodily functions. The primary causes of CKD include diabetes, high blood pressure, and obesity. Other contributing factors include conditions such as glomerulonephritis, polycystic kidney disease, and kidney damage caused by gout, among others.

Siriraj Piyamaharajkarun Hospital (2023) has stated that chronic kidney disease is a condition characterized by a gradual decline in kidney function, as evidenced by abnormal glomerular filtration rates (eGFR) or other indicators such as protein leakage in the urine or radiological abnormalities. These symptoms persist for more than three months, signaling the presence of kidney dysfunction. In the early stages, chronic kidney disease (CKD) often shows no symptoms, and many individuals may not be aware they have the condition unless they undergo blood or urine tests. However, as kidney function declines and fewer nephrons remain, symptoms of waste buildup in the bloodstream begin to appear. These can include lethargy, nausea, and vomiting, indicating the body's inability to filter toxins effectively.

Figure 7 displays the comparison of kidneys at each stage

From (https://lifeoptions.org/learn-about-kidney-disease/causes-and-stages/)

Overview of Current Chronic Kidney Screening Methods

Nakornthon Hospital (2024) has stated that to prevent the progression of kidney disease and monitor existing conditions, a comprehensive evaluation is necessary. This typically includes a physical examination by a nephrologist, followed by a review of examination results. Additionally, a blood test is conducted to assess kidney function, with particular attention to urea and creatinine levels (BUN and Creatinine), which provide key indicators of renal health. The kidneys excrete waste, including substances like urea and creatinine, which are used to calculate the glomerular filtration rate (eGFR) — an indicator of kidney function. Additionally, blood tests check electrolyte levels, including sodium (Na), potassium (K), and bicarbonate (CO_2), to assess the body's mineral balance and kidney health. Blood tests are conducted to check fasting blood sugar (FBS), assess average blood sugar levels over time using HbA1c, and measure uric acid levels. A preliminary urine test (Urine Examination; UA) is also performed to check for albumin protein, with specific attention to microalbumin levels (Urine microalbumin; UMA), which can indicate kidney damage. An ultrasound examination of the kidneys, urethra, and bladder (Ultrasound Kidney, Urethra, Bladder) is commonly used as a screening test for kidney disease. To ensure accurate results, patients are required to fast for 8-12 hours prior to the procedure.

Retina

National Science Museum (2021) has stated that the retina is a thin layer of tissue at the back of the eye that contains photoreceptor cells. When light enters the eye through the pupil and lens, it is focused onto the retina, which functions similarly to the film in a camera, capturing visual information for the brain to process. The cells in the retina convert light signals into electrical nerve impulses, which are then transmitted via the optic nerve to the brain's occipital lobe for visual processing.

The retina can indicate various diseases. For instance, as noted by the National Science Museum (2021), diabetic retinopathy is caused by abnormal blood vessels in the retina, leading to the leakage of blood and fluid into the retinal tissue. This condition can impair vision if left untreated.

Patients with diabetic retinopathy often experience blurred vision, reduced clarity, and, in severe cases, complete vision loss (American Diabetes Association, 2023). Additionally, according to Bangkok Hospital (2024), Age-Related Macular Degeneration (AMD) is another significant retinal disease affecting vision, especially among older individuals. Caused by the degeneration of photoreceptor cells in the retina. This causes abnormal vision in the center, such as seeing distorted images, Or there is a black spot in the center of the image (National Eye Institute, 2022). Additionally, glaucoma is the result of damage to the optic nerve.

Glaucoma, often caused by elevated eye pressure, gradually reduces peripheral vision, potentially leading to tunnel vision where only the central field remains visible (Glaucoma Research Foundation, 2023). Retinal detachment occurs when the retina separates from the underlying tissue, causing symptoms such as shadows or curtains obscuring part of the vision, flashes of light, or floating specks in the field of view (American Academy of Ophthalmology, 2023).

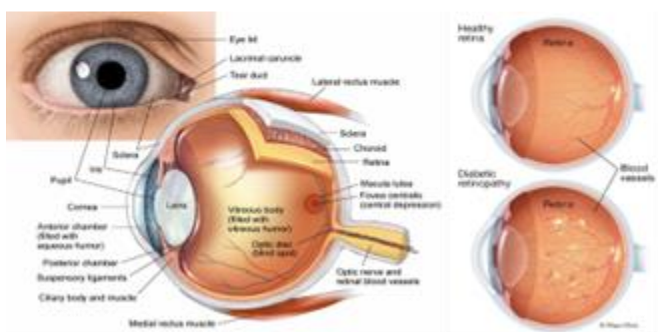


Figure 8 illustrates the different characteristics of patients' retinal images

From (The Organization of the Retina and Visual System - Crystalline Lens)

Chronic Kidney Disease screening using retinal images

Singapore National Eye Centre (2020) has stated that Digital retinal imaging can aid in screening and detecting chronic kidney disease by identifying microvascular abnormalities in the retina, such as retinal disorders, narrowing, or dilation of capillaries. These changes reflect the impact of systemic conditions on small blood vessels and can serve as early indicators of kidney disease progression.

Zhongshan Ophthalmic Center (2023) that Chronic kidney failure can be identified through retinal signs, including: Retinopathies, Cotton Wool Spot, Bleeding in the retinal capillaries, retinal swelling, anemia caused by kidney disease, elevated blood cholesterol levels, and changes in the diameter of retinal arteries, including the central retinal artery, can all serve as indicators of systemic health issues related to chronic kidney disease.

Suitable light waves for retinal imaging

Srinakharinwirot University (2024) said that A retinal camera must utilize four specific light waves for imaging:

1. **Light Wave 1**: Wavelengths between 435–500 nanometers.
2. **Light Wave 2**: Wavelengths between 500–585 nanometers.
3. **Light Wave 3**: Wavelengths between 585–640 nanometers.
4. **Light Wave 4**: (Details about the range, if applicable, could be included here for completeness.)

If the retinal imaging device incorporates these specific light waves, it can capture clear and detailed images of the retina while ensuring safety for the user's eyes. This design effectively balances precision and non-invasive operation, making it suitable for regular diagnostic use. Penn State Hershey Eye Center (2024) said that Filters with peak wavelengths of 490 nm, 540–570 nm, and 615 nm are commonly used in monochromatic retinal imaging. A fluorescence stimulation filter with a peak wavelength of 490 nm can also function effectively as a single-color blue-green filter, enabling detailed imaging while optimizing the capture of specific retinal features.

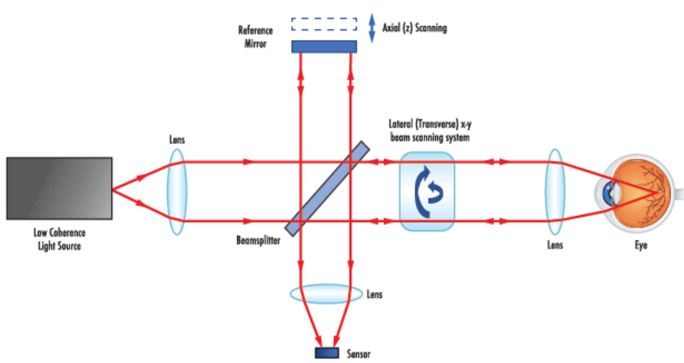


Figure 9 shows the diagram of the working principle of a retinal imaging light source
From (https://www.edmundoptics.com/knowledge-center/application-notes/optics/optical-coherence-tomography/)

Procedure and Process

KidneyLifePlus+ has been divided into five phases as follows:

Phase 1: The development team conducted interviews with individuals affected by chronic kidney failure and consulted with Mrs. Nongnuch Phongsatui, Director of the Moo Ban Public Health Volunteer Team (VHVH), to understand community screening challenges. We also worked with Dr. Thapanaphong Rakkanchanan, Dr. Kornprom Phikunkaew, and Prof. Dr. Sukrit Sucharitkul from Chiang Mai University to ensure the project effectively addresses these issues and meets user needs.

Phase 2: The development team began work on the KidneyLifePlus+ project by dividing the process into three parts. **First**, **we focused on developing the artificial intelligence system**, combining the ResNet50, YOLOv8, and U-Net models into a unified AI framework called **NephroNet**. This AI system was designed to screen for chronic kidney disease and identify associated risk factors with high accuracy. **Second**, **the team focused on application and database system development**. We used React Native combined with Expo to build the application, while Firebase was utilized for the database system and backend development. **Third, the team developed the RetinaScope hardware**. Using the Onshape program, we designed the device as a 3D model, which was then produced using a 3D printer. The device incorporates an ocular lens to enlarge retinal images, ensuring high-quality equipment for maximum efficiency in the upcoming testing phase.

Phase 3: The development team tested the KidneyLifePlus+ application and RetinaScope device with a group of sample users from the Ban Klang Subdistrict community in Lamphun Province. The test was conducted in collaboration with Ms. Aoonjai Somrit, the head of public health in Moo Ban, to assess user satisfaction with the system.

Phase 4: The team is seeking approval for human research ethics to collaborate with the Faculty of Medicine at Chiang Mai University to collect retinal image data from kidney disease patients in phases 1-5 at Suan Dok Hospital. This will improve the AI system’s accuracy. The team is also pursuing patent registration, ISO13485:2016, GMP certification, and compliance with the Computer Management Act, medical equipment regulations, and ISO/IEC 27001 standards, as well as registering the software as a Medical Device (SaMD) under TIS standards.

Phase 5: Publishing KidneyLifePlus+ for practical use and make chronic kidney disease screening easily accessible to users, allowing them to perform the screening conveniently anytime and anywhere.

Experiments

Phase – 1: AI Development

To evaluate the effectiveness of artificial intelligence models in detecting risk factors from retinal images.

Phase 1.0. Data Preparation

- **Data Collection**

  Collect retina picture dataset from patients with chronic kidney disease at various stages and people without chronic kidney disease altogether 500 people to make our dataset have at least 4,000 pictures each class.

- **Data Preprocessing**
  Do data augmentation on dataset to make more dataset and start to train AI. Moreover, prepare the image by converting it to grayscale, applying a fixed threshold, and detecting contours.

Phase 1.1. Find the best AI Model in Classifying Risk Factors for Kidney Disease

Problem: What type of AI model is most effective in classifying retinal images of patients with chronic kidney disease and identifying risk factors that indicate the presence of the disease with the most accurate?

Hypothesis: The Convolutional Neural Network (CNN) model, specifically the EfficientNetB0 model, can classifies retinal images of kidney disease patients and identifies risk factors that indicate the likelihood of developing kidney disease.

Data Analysis: ResNet-50 effectively classifies retinal images of patients with chronic kidney disease into risk factor categories

Phase 1.2. Identify the optimal fine-tuning approach for the AI model

Problem: What hyperparameters can enhance the precision of an AI model in classifying retinal images by disease type and associated risk factors?

Hypothesis: Hyperparameters α (Learning Rate) = 0.001, λ (L2 Regularization Penalty) = 0.01, Optimizer = Adam (Adaptive Moment Estimation), # of Dense Layers = 4 will enhance the model's capability and precision in classifying retinal images.

Data Analysis: After adjusting hyperparameters (learning rate, L2 regularization penalty, optimizer, and dense layers), the model's accuracy improved. Enhanced the ResNet-50 model, achieving 95.5% accuracy.

Phase 1.3. Identify the most effective AI model for detecting blood spots and cotton wool spots in retinal images

Problem: Which AI model can most accurately identify points where colored crystals form in the eyes and detect blood spots within the eyes?

Hypothesis: The Convolutional Neural Network (CNN) architecture, specifically the Object Detection YOLOv5 model, can detect colored crystals and blood spot with the most accurate.

Data Analysis: YOLOv8 on PyTorch achieved the highest accuracy in detecting crystal deposits and blood spots within eye.

Phase – 2: Hardware Development

Phase 2.1. Testing the Retina Scope's effectiveness in capturing high-quality retinal images

Problem: Which retinal imaging method produces the highest image quality for analyzing and identifying the risk of developing kidney disease?

Hypothesis: A method that utilizes the light source from a smartphone can achieve the best image quality for capturing retinal images, which can then be analyzed to assess the risk of kidney disease.

Data Analysis: By using the phone's light source, the quality of the retinal images is enhanced, making it suitable for analyzing risk factors.

Phase – 3: Trial with a group of volunteers

Phase 3.1. Evaluating the quality and user satisfaction of the product based on feedback from volunteers

Problem: Were the groups of volunteers and experts satisfied with the KidneyLifePlus+ screening tool?

Hypothesis: The groups of volunteers and experts satisfied with the KidneyLifePlus+ screening tool.

Data Analysis: Most of the sample group were satisfied with the screening. KidneyLifePlus+

Result

Phase-1: AI Development

To evaluate the effectiveness of artificial intelligence models in detecting risk factors from retinal images.

Phase 1.1. Find the best AI Model in Classifying Risk Factors for Kidney Disease

Table 1: Comparison of AI Model Accuracy

AI Models	1		2		3	
	Accuracy	Time (s)	Accuracy	Time (s)	Accuracy	Time (s)
ResNet-50	87.2	5.95	87	6.26	85.9	6.12
EfficientNetB0	85.6	4.25	85.8	6.15	84.1	6.07
VGG19	83.9	6.06	81.9	6.22	81.7	6.28

From testing 3 AI model, the artificial intelligence model with a Convolutional Neural Network (CNN) architecture using ResNet-50 effectively classifies retinal images of patients with chronic kidney disease into risk factor categories. The model achieved an average accuracy of 86.7% and a processing speed of 0.017 seconds per image.

Phase 1.2. Identify the optimal fine-tuning approach for the AI model.

Table 2: Adjusting Optimizer

Times	Optimizer	Accuracy	Loss	Time (s)
1	Adam	0.831	0.543	270.12
2		0.832	0.56	317.01
3		0.817	0.554	266.54
1	RMSprop	0.836	0.559	290.48
2		0.834	0.573	288.23
3		0.829	0.57	253.7

Table 3: Adjusting # of dense layer

Times	Optimizer	Accuracy	Loss
1	3	0.856	0.41
2		0.848	0.427
1	4	0.882	0.365
2		0.875	0.379
1	5	0.835	0.42
2		0.827	0.443

After adjusting hyperparameters (learning rate, L2 regularization penalty, optimizer, and dense layers), the model's accuracy improved. Key hyperparameters contributing to accuracy were identified. Fine-tuning further enhanced the ResNet-50 model, achieving 95.5% accuracy.

Phase 1.3. Identify the most effective AI model for detecting blood spots and cotton wool spots in retinal images.

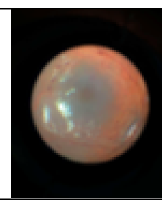
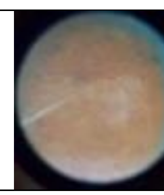
Table 4: Comparison of AI Accuracy in detecting blood spots and cotton wool spots.

AI Model for segmentation	1	2	3
	Accuracy	Accuracy	Accuracy
YOLOv8 on PyTorch	87	84.3	92.4
EfficientDet	76.3	81.6	84.2
Mask R-CNN on Keras	64.7	78.4	81.7

The experiment found that YOLOv8 on PyTorch achieved the highest accuracy in detecting crystal deposits and blood spots in the eye compared to other artificial intelligence models. The average accuracy from the experiments demonstrated that an appropriately designed architecture can work efficiently for object detection.

Phase 2: Testing the Retina Scope's effectiveness in capturing high-quality retinal images.

Table 5: Comparison table of the image quality of retinal photographs taken through Retina Scope using a simulated eye under natural light and with light on.

Type of Light Source	1	2	3
Light Source			
Quality graded by an ophthalmologist.	4	4	5
Natural Light Source			
Quality graded by an ophthalmologist.	1	1	2

The quality of images graded by an ophthalmologist using different light sources showed varying results. For the first light source, the quality was rated 4 for two instances and 5 for one instance. In contrast, the quality of images taken with a natural light source was rated lower, with ratings of 1 for two instances and 2 for one instance.

Phase 3: Evaluating the quality and user satisfaction of the product based on feedback from volunteers.

Table 6: Satisfaction of 10 volunteers who underwent kidney disease screening with KidneyLifePlus+

	Satisfaction	Number of people	Calculated as a percentage
First impression of the screening using the new method.	Most	6	60
	Medium	3	30
	Least	1	10

Table 7: Satisfaction of 6 experts who working in local hospital

	Satisfaction	Number of people	Calculated as a percentage
First impression of the screening using the new method.	Most	3	50
	Medium	1	16.67
	Least	2	33.33

An evaluation of the new screening method in KidneyLifePlus+ showed positive results: 60% of participants were highly satisfied, 30% were moderately satisfied, and 10% were dissatisfied. This suggests general approval of the method. Experts from local hospitals also indicated that KidneyLifePlus+ could significantly impact proactive chronic kidney disease screening, enhancing early detection and accessibility.

Problems and obstacles

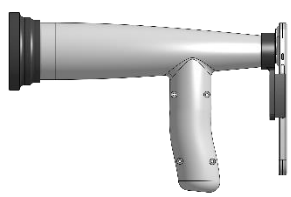
- Currently, the dataset is small, which causes the AI model to experience overfitting.
- In cases where there is no internet access, the KidneyLifePlus+ application cannot be used.

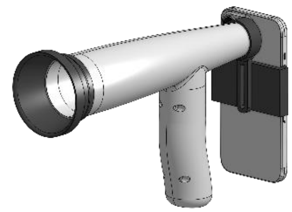
Solutions and Future Development Plans

- Collaborate with the Faculty of Medicine at Chiang Mai University to collect additional datasets for improving the AI model's accuracy.
- Adjust hyperparameters during model training to achieve optimal accuracy.
- Obtain ISO 13485 certification to bring KidneyLifePlus+ to market.

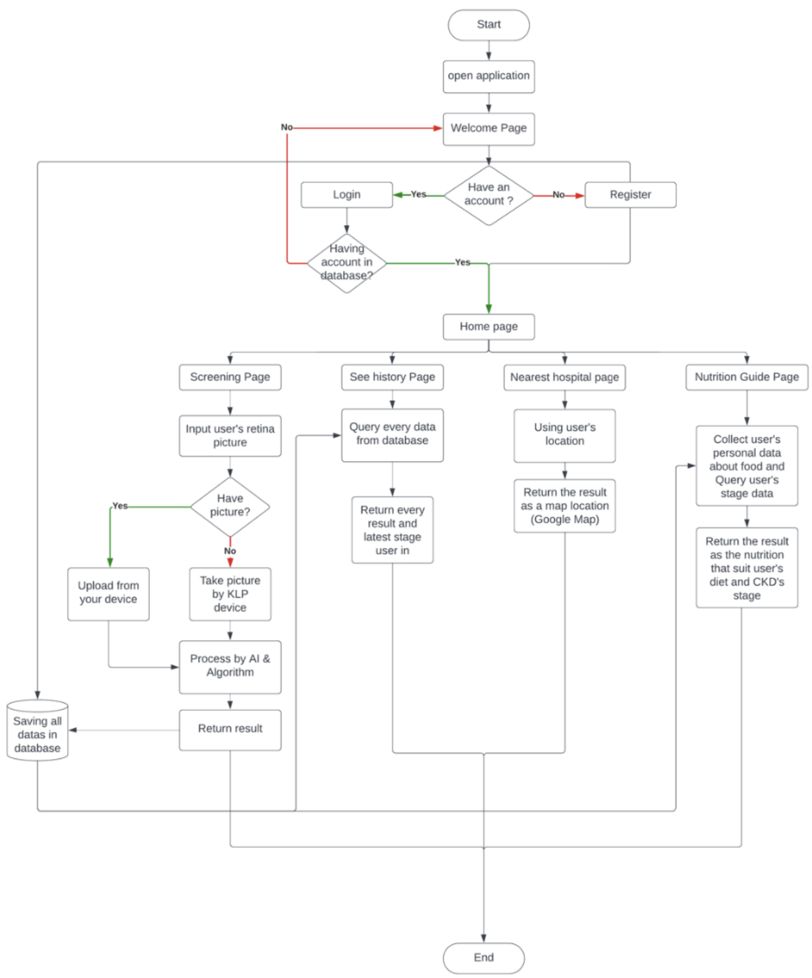
Prototype and Process Flow Diagram

Prototype





Process Flow Diagram



Conclusion

This study aimed to evaluate the effectiveness of the ResNet-50-based Convolutional Neural Network (CNN) in classifying retinal images for assessing chronic kidney disease (CKD) risk factors. The model demonstrated an average accuracy of 86.7% and a processing speed of 0.017 seconds per image, highlighting its potential for real-time applications in CKD risk assessment. Fine-tuning the ResNet-50 model, through adjustments to hyperparameters such as learning rate, regularization, and dense layers, further improved its performance, achieving an accuracy of 95.5%. Additionally, YOLOv8 on PyTorch emerged as the most effective model for detecting specific retinal features like blood spots and cotton wool spots, with an average accuracy of 92.4%, outperforming EfficientDet and Mask R-CNN.

The study also tested the Retina Scope, a device designed to capture high-quality retinal images. Under controlled light conditions, ophthalmologists graded the images at 4–5 in quality, demonstrating the device's effectiveness. However, images captured in natural light scored significantly lower, underscoring the importance of stable lighting for optimal results. These findings suggest that the Retina Scope, when used in appropriate settings, can be an integral component of an efficient CKD screening system.

Feedback from users and experts reinforced the viability of the KidneyLifePlus+ system. Among volunteers, 60% expressed high satisfaction with the screening method, while 30% were moderately satisfied. Expert feedback from local hospitals indicated that 50% of respondents were highly impressed with the system's ability to enhance proactive CKD screening and improve early detection. However, some experts pointed out the need for further refinements to meet diverse clinical needs.

These results underscore the transformative potential of AI-powered solutions like the ResNet-50 CNN in healthcare diagnostics. By offering faster, more accessible, and reliable screening methods, KidneyLifePlus+ addresses critical gaps in CKD screening. Nonetheless, the study's limitations, such as a relatively small sample size and the need for testing across diverse patient populations, must be addressed in future research. Expanding the dataset to include more diverse retinal features, such as retinal thickness, and conducting clinical evaluations will be essential for maximizing the system’s accuracy and applicability. With continued refinement, KidneyLifePlus+ could play a pivotal role in revolutionizing CKD diagnostics and enhancing patient care worldwide.

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Appendix

KidneyLifePlus+ participation and awards received

Month/Year	Competitions	Awards	Evidence
Oct 2023	Samsung Solve for Tomorrow	Winner and Popular vote	
Sep 2023	Field trip: Visit Samsung Electronics Headquarter in Korea	-	
Aug 2024	Change Innovation Awards	2^{nd} Runner-Up	
Aug 2024	National Software Contest	Honorable Mention	
Aug 2024	Science Project – Northern Region	Honorable Mention	

Aug 2024	Thailand Innovation Awards	1^{st} Runner-up and Best Pitching Award Winner	
Aug 2024	Thailand ICT Awards	1^{st} Runner-Up	

【評語】090030

1. Novelty and Significance:

   KidneyLifePlus+ represents a novel approach to addressing the critical challenge of early chronic kidney disease (CKD) detection. The project's significance lies in its potential to revolutionize CKD screening, particularly in resource-constrained settings. By leveraging advanced AI technologies to analyze retinal images, the system offers a non-invasive, rapid, and potentially more accessible method for early CKD detection. This innovation could have far-reaching implications for global health, especially considering the high prevalence of CKD and the low awareness rates among affected individuals. The combination of AI-powered software with proprietary hardware for capturing high-resolution retinal images demonstrates a comprehensive approach to solving a complex healthcare challenge.

2. Strengths:

   The project's primary strength lies in its multifaceted approach to CKD detection. The integration of multiple advanced machine learning models (U-net, ResNet-50, and YOLO v8) for analyzing retinal images showcases a sophisticated technical foundation. The development of proprietary hardware capable of capturing high-quality retinal images comparable to hospital-grade equipment is another significant strength, as it ensures the quality of input data for the AI models. Furthermore, the focus on affordability and ease of use makes the system suitable for deployment in community healthcare settings, potentially expanding access to CKD screening beyond traditional clinical environments. This approach addresses key limitations of existing screening methods, offering a solution that is both rapid and cost-effective.

3. Weaknesses:

   Despite its innovative approach, the project has several areas that require further development and clarification. The study appears to have been conducted on a relatively small dataset, which could limit the generalizability of the findings. A larger, more diverse dataset is crucial for validating the accuracy and robustness of the AI models across different populations and retinal conditions. The models' focus on specific retinal features, while important, may not encompass the full range of potential biomarkers for CKD, potentially limiting diagnostic accuracy. Additionally, the lack of comprehensive demographic and clinical information about the study participants (such as age, gender, blood pressure, and diabetes history) in the presented results makes it difficult to fully assess the system's performance across different patient subgroups. Finally, the absence of clear data on the number of CKD patients and healthy individuals analyzed, as well as any failed analyses, limits the ability to evaluate the system's overall effectiveness and reliability.