OCULAR PROJECT

ANNUAL REPORT

MAKERERE UNIVERSITY

OCULAR
AUTOMATING MICROSCOPY

2024

www.ocular-project.com

Foreword

Dr. Rose Nakasi's core research intends to broaden the use of artificial intelligence (AI) in health applications, putting it at the forefront of technological advancement. She provides a dynamic setting for increased academic progress and experimentation in the AI Health research lab. Her lab provides an enabling environment for active learning, testing, developing, and nurturing critical academic skills.

This lab promotes interdisciplinary cooperation and synergistic actions to develop AI in healthcare and enable a knowledge-based economy.

The AI health research lab is well-equipped with cutting-edge technology and technical knowledge, and it aims to provide students and scientists with unique possibilities to experiment and advance pioneer science and technology that works well for health applications.

Her work serves as a solid foundation for building long-term academic and meaningful professional relationships. Dr. Nakasi's lab also supports the creation of long-term pipelines and academic activities. Finally, the lab encourages long-term relationships, intellectual activities, and friendships between students and scientists.

Dr. Nakasi's lab project team has created an AI-driven malaria detection application that is currently being tested at Kiruddu National Referral Hospital, and work is also being done to design and train an AI-driven cervical cancer application for real-time diagnostics.

It is incredibly thrilling to see all of the current progress toward attaining the project's specified goals. Dr. Nakasi's career and team are headed in the right direction.

As this project nears the halfway point and enters the last stage, we should anticipate to see further progress. At the end of this project, we expect improved health outcomes, a cohort of trained health personnel, and the full adoption of these innovations in healthcare institutions throughout Uganda and beyond.

Message from the Principal Investigator

Dear Colleagues and Partners,

I am thrilled to present the first edition of our Annual Report, showcasing the remarkable achievements of the Mak AI-Health Lab and the Ocular Project.
This initiative, focused on automating microscopy for malaria, tuberculosis, and cervical cancer diagnosis, has made significant progress thanks to the dedication and expertise of our team.

Since inception, we've focused on developing and testing AI algorithms designed to transform diagnostic practices. Our initial versions for detecting malaria and tuberculosis in blood and sputum samples demonstrated promising accuracy. These results are being refined to ensure even greater reliability and effectiveness.

A key milestone has been our pilot testing in select healthcare facilities across Uganda. The feedback from healthcare professionals has been invaluable, helping us improve diagnostic speed and accuracy, and ensuring the technology integrates seamlessly into everyday practices.

Our success is driven by strong partnerships with local health institutions, research centers, and international organizations. These collaborations have enhanced our AI models by providing access to diverse data sets. We've also conducted training sessions for healthcare workers, equipping them with skills to use our AI-powered microscopy tools effectively. More to this, we launched community awareness campaigns to educate the public on the benefits of AI in healthcare, aiming to build trust and acceptance of this innovative technology.

Looking ahead, we plan to expand pilot testing to more healthcare facilities, representing both urban and rural areas, while further enhancing our AI models for diagnostics. Regular stakeholder meetings will continue to guide our progress and keep us aligned to our shared goals. I extend my deepest gratitude to the entire team for their dedication and to our partners for their unwavering support.
Together, we are transforming healthcare diagnostics and making a lasting impact.
Thank you for your partnership.

Warm regards, Dr. Rose Nakasi
Project Lead, Ocular project

Message from Principal Laboratory Technician

In Uganda and across many Sub-Saharan African countries, microscopy remains the cornerstone of diagnosing infectious diseases. However, one of the significant challenges is the shortage of trained and skilled laboratory personnel, particularly at lower-tier healthcare facilities where specialists are scarce. This shortage severely impacts both the efficiency and accuracy of diagnostic results. The Ocular project seeks to address this critical gap by incorporating Artificial Intelligence (AI) into existing laboratory infrastructure. By integrating AI modules into smartphones, which can be paired with conventional microscopes, the project aims to revolutionize healthcare delivery and improve patient outcomes by enhancing the accuracy and speed of diagnostic processes.

For instance, a traditional expert smear examination typically takes around 15 minutes to yield a reliable result. With the introduction of AI-based decision support systems in microscopy, this time could be reduced to just 2-3 minutes—cutting the time required by at least 25%. This efficiency gain is remarkable, freeing up laboratory staff to process more samples and significantly reduce the overall turnaround time (TAT). Moreover, faster and more accurate results can reduce the risk of patients resorting to self-medication or receiving empiric treatment due to delayed diagnoses—both of which contribute to the rise of drug resistance.

In essence, AI-enhanced automated microscopy represents the future of diagnostic examinations, particularly in regions where access to advanced diagnostic tools is limited. As technology continues to evolve, adopting AI-driven approaches in microscopy will be key to advancing medical care and improving patient management. The time to embrace this innovation is now.

Dr. Alfred Andama
Chief Laboratory Technician

Executive Summary

The Makerere University AI-Health Lab is revolutionizing disease diagnostics in Uganda through cutting-edge AI-driven solutions. Since its launch in September 2023, the Ocular Project has integrated Artificial Intelligence with mobile microscopy to improve the diagnosis of critical diseases like Malaria, Tuberculosis (TB), and Cervical Cancer. By addressing the urgent need for timely and accurate diagnostics in resource-limited areas, this project is committed to providing accessible healthcare solutions for some of the country's most pressing challenges.

The Ocular Project aims to develop a mobile diagnostic tool that leverages AI to enhance disease detection at the point of care. In Uganda, limited diagnostic capacity has often delayed treatment, worsening health outcomes. This initiative seeks to improve health outcomes through AI-powered diagnostics, monitoring frameworks, and disseminating findings to key stakeholders. A significant achievement has been the creation of 3D-printed microscope adapters that enable smartphones to capture and analyze images, streamlining the diagnostic process. The project's AI-powered app for malaria detection has demonstrated increased diagnostic accuracy, and data collection is underway at five government hospitals and the Uganda Cancer Institute.

Strong partnerships with healthcare institutions and community stakeholders have been critical to the project's success, enhancing visibility and support. Training sessions have equipped healthcare workers with essential diagnostic skills and familiarity with AI technologies. The project's research has been shared at both national and international forums, contributing to global knowledge on AI's role in healthcare. Looking ahead, the project plans to expand data collection, improve diagnostic accuracy for TB and cervical cancer, and scale up training programs. By fostering collaborations with international research institutions and tech companies, the Ocular Project is poised to make a lasting impact on Uganda's healthcare system and beyond.

Introduction

Africa's healthcare system faces significant challenges due to limited technical expertise and a shortage of specialized equipment, severely undermining its diagnostic capacity. Delays and inaccuracies in diagnoses lead to improper or late treatments, increasing both morbidity and mortality. The absence of reliable diagnostics results in patients receiving unnecessary or inappropriate treatments, which wastes resources and burdens the system with repeat visits, extended treatment regimens, and escalating drug resistance. Moreover, the lack of timely data hinders effective disease surveillance, complicating efforts to track outbreaks and allocate resources efficiently, further deepening healthcare disparities.

Malaria, TB, and Cervical Cancer present serious public health challenges in Uganda, necessitating ongoing investment in diagnostic solutions. Malaria alone accounts for 30-40% of outpatient visits and 20% of hospital admissions, placing Uganda among the highest transmission rates globally. TB, with 200-250 cases per 100,000 people, and the rise of drug-resistant TB (MDR-TB), further underscores the need for better diagnostics. Cervical cancer, the leading cancer among Ugandan women, represents 40% of female cancer cases, driven by inadequate screening and late diagnoses.

Effective management of these diseases requires both skilled personnel and reliable diagnostic tools. Microscopy is essential in disease diagnosis and although microscopes are common in Uganda and other developing counties, there is a shortage of skilled laboratory personnel, limiting access to quality diagnostics, especially in areas with endemic diseases like malaria and cervical cancer.

As we reflect on the project's first year, we highlight our progress in building, testing, and refining AI-Powered deep learning algorithms. This transformative technology, can significantly enhance diagnostic accuracy by automatically detecting pathogens such as malaria and TB, reducing diagnostic errors and speeding up treatment decisions. It has already begun shaping the future of medical diagnostics in Uganda and laying the groundwork for broader regional and global applications.

Project
OVERVIEW

Project Overview

This initiative aims to transform disease diagnosis by integrating AI with mobile microscopy, specifically targeting malaria, tuberculosis, and cervical cancer. The project's goal is to develop and deploy a mobile diagnostic tool that leverages AI to provide highly accurate, point-of-care disease detection. By streamlining the diagnostic process, this solution offers real-time, reliable results while minimizing the errors and delays typically seen in traditional manual microscopy.

Key Objectives

- Develop AI-based standardized approaches for deployable field microscopy diagnosis of malaria, tuberculosis, and cervical Cancer.
- Build a complementary framework for surveillance, present research findings, and produce openly available data and AI tools (training datasets curated in this study and some benchmarking surveillance models will be made publicly available)
- Prepare manuscripts and result dissemination for different stakeholders.

Scope of the project

This project focuses on transforming microscopy-based diagnosis for malaria, TB, and cervical cancer, with the potential to expand to other diseases. A key feature is a Teaching Aid System designed to provide real-time guidance and feedback, significantly improving diagnostic accuracy while providing continuous training for microscopists and other laboratory professionals.

In addition, the project is developing an advanced machine learning framework that integrates seamlessly with existing disease surveillance system, enabling real-time data collection, analysis, and outbreak prediction.

Spanning three years, the project will be piloted across Uganda's four regions. During this time, efforts will concentrate on developing and testing the AI model, deploying it within clinical and healthcare settings, and assessing its impact on both individuals and the healthcare system.

Key Project Activities

The AI-powered diagnostic tool is set to transform disease diagnosis in clinical settings by overcoming the limitations of traditional methods. By integrating AI with microscopy, the tool empowers diagnosticians to make real-time, data-driven decisions at the point of care, significantly improving diagnostic outcomes. This innovative solution offers faster and more reliable diagnoses.

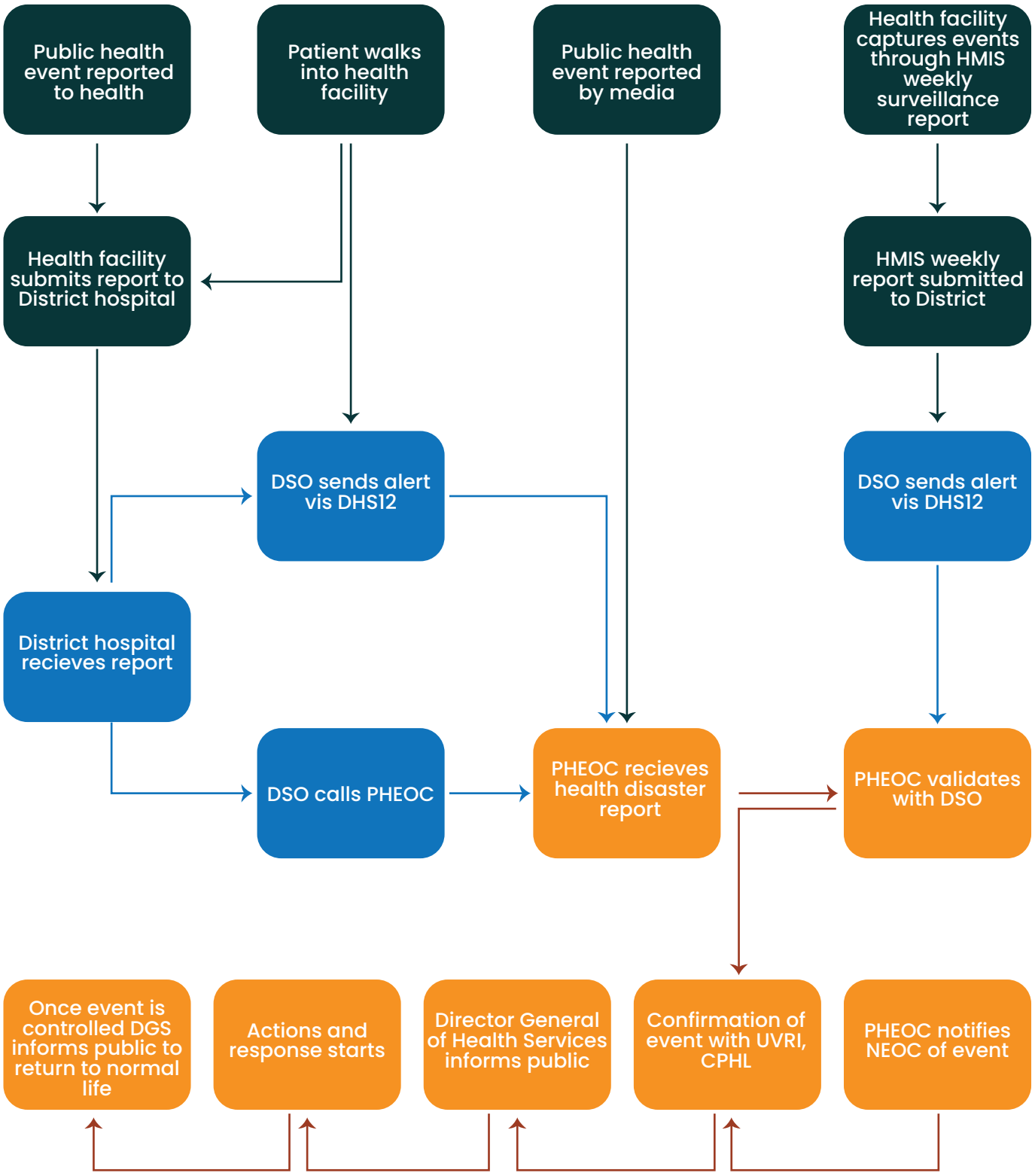
The following sections will explore the tool's design, functionality, and impact on clinical workflows, highlighting how it is reshaping the future of disease diagnostics.

AI-powered diagnostic tool

The solution features a 3D-printable adapter that securely attaches any type of smartphone to the eyepiece of a microscope. The diagnosticians is able to capture high-quality images directly through the smartphone. Once captured, these images are processed by an AI-powered application that detects and classifies parasites and pathogens and returns a diagnosis..

Complementary framework

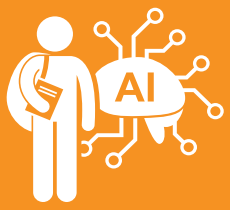
The complementary framework integrates machine learning (ML) into the existing Integrated Disease Surveillance system to enable real-time data collection, analysis, and presentation. The primary objective is to digitize and automate the flow of patient data from health facilities to district and national levels, making data more accessible for decision-makers.


Public health event reported to health
Patient walks into health facility
Public health event reported by media
Health facility captures events through HMIS weekly surveillance report
Health facility submits report to District hospital
HMIS weekly report submitted to District
DSO sends alert vis DHS12
DSO sends alert vis DHS12
District hospital recieves report
DSO calls PHEOC
PHEOC recieves health disaster report
PHEOC validates with DSO
Once event is controlled DGS informs public to return to normal life
Actions and response starts
Director General of Health Services informs public
Confirmation of event with UVRI, CPHL
PHEOC notifies NEOC of event

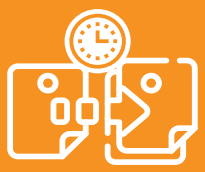
Level	Function	The Intervention
Health Facility Level (Green) All institutions (public and private health services providers) with outpatient and/or in-patient facilities are defined as a "health facility.	• Collects real-time data on patient registration, case reporting, and laboratory testing. • Implements routine reporting through health management information systems (HMIS). • Conducts contact tracing for individuals linked to confirmed cases.	• **Automated Data Capture:** Use ML models to convert unstructured patient records into structured formats. • **Natural Language Processing (NLP):** Extract relevant information from clinical notes to identify potential disease cases. • **Real-time Data Integration:** Integrate data from various sources for comprehensive analysis. • **ML-Aided Dashboards:** Visualize data for better decision-making.
District Level (Blue) The surveillance unit at the District plans, implements, supervises and monitors implementation of IDSR.	• Collects and reviews surveillance data from health facilities and the community. • Assists facilities in updating reports on disease trends and conditions.	• **Routine Reporting:** Generate and disseminate reports for all conditions. • **Alert Systems:** Implement ML-driven alerts for potential outbreaks and changes in disease patterns. • **Pattern Recognition:** Use ML models to identify patterns and anomalies in health data.
National Level (Red) The Ministry of Health and other Ministries, Departments and Agencies (including; national referral hospitals, national reference laboratories and national medical stores) where surveillance policies, guidelines, SOPs and resources are allocated.	• Ensures timely reporting of priority diseases to relevant programs and stakeholders. • Analyzes national data for actionable insights and track trends over time.	• **Predictive Modeling:** Forecast disease outbreaks using predictive analytics. • **Information Dissemination:** Utilize NLP tools to summarize and share important findings with healthcare workers and authorities.

Through the development of ML models, the framework will predict the incidence of malaria, tuberculosis, and cervical cancer, enhancing outbreak prediction and response capabilities by leveraging data from health facilities, registries, and socio-economic sources.

Other Project Activities



Training for healthcare workers to use the AI-integrated system, enhancing their skills for future technologies.



Real-time data integration with platforms like DHIS2 to enhance disease surveillance.

Data collection and labelling of over 6,000 images to be used to improve the AI model

Develop a teaching aid system to provide hands-on microscopy training for lab technicians, health care workers and medical students

Progress & **Achievements**

Progress & Achievements

The past year has seen significant progress in all key areas of the project, with numerous activities aimed at achieving our objectives. Key efforts included securing the necessary approvals to access and use health data, developing the diagnostic tool, and collaborating with healthcare institutions to provide medical personnel with hands-on experience with the tool and train them in data collection essential for training the AI model.
The following sections outline the main activities conducted during this reporting period, highlighting key milestones and achievements that have contributed to the project's impact and growth.

Approvals and Permissions

The project secured both administrative and Institutional Review Board (IRB) approvals for Malaria and Cervical Cancer. These approvals were crucial in ensuring compliance with ethical standards and regulations governing health research in Uganda.

Collaborating closely with the Ministry of Health, we worked to align our project goals with national health priorities, particularly the fight against Malaria, and Cervical Cancer, which are significant public health challenges in Uganda. The Ministry's support facilitated access to health facilities and resources necessary for the study, fostering a collaborative environment that emphasizes the importance of high-quality, evidence-based diagnostics.

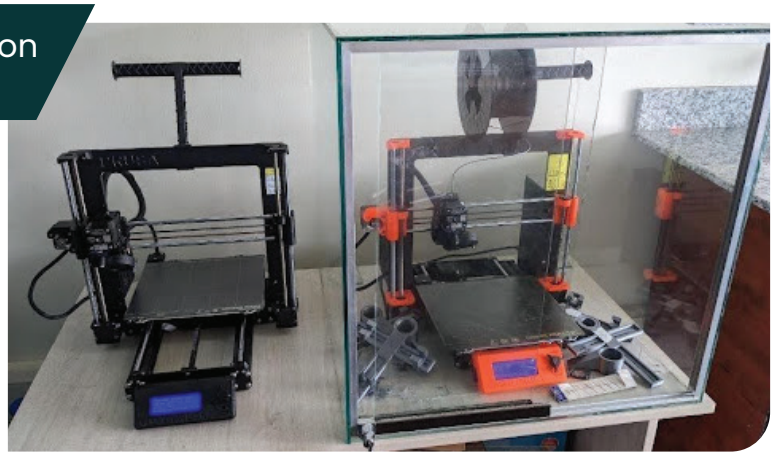
This milestone marks a significant step forward in our project, enabling us to gather essential data that will inform the development of our AI-powered diagnostic tools. The data collected will not only enhance our understanding of disease patterns but also help tailor interventions that address the specific needs of affected populations. The insights gained from these hospitals and the cancer institute will contribute significantly to advancing our objectives and ultimately improving healthcare outcomes in Uganda.

Project activities | Adapter design and Fabrication

The project successfully designed and manufactured 3D-printed adapters for microscopes utilized in diagnosing malaria, tuberculosis, and cervical cancer. These adapters underwent field testing and were refined based on feedback from health centers. Additionally, we are currently documenting all experiments and surveys conducted to guide the modification process of the adapters.

Parts of adapter after fabrication ready for assembly

Adapter Production Process setup

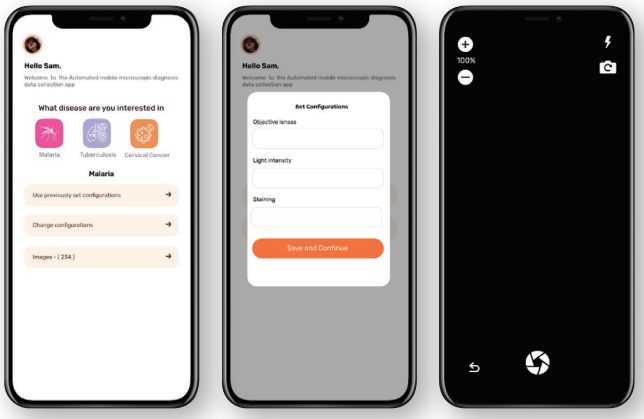


Testing

Testing of the Cervical cancer adapter at Uganda Cancer Institute (UCI)

Project activities | Application development

The development process focused on three key tools: a data collection app, a malaria diagnostic app and a microscopy teaching aid.

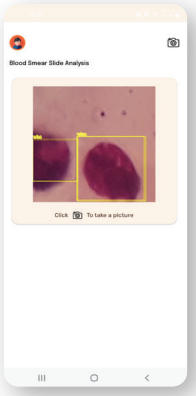


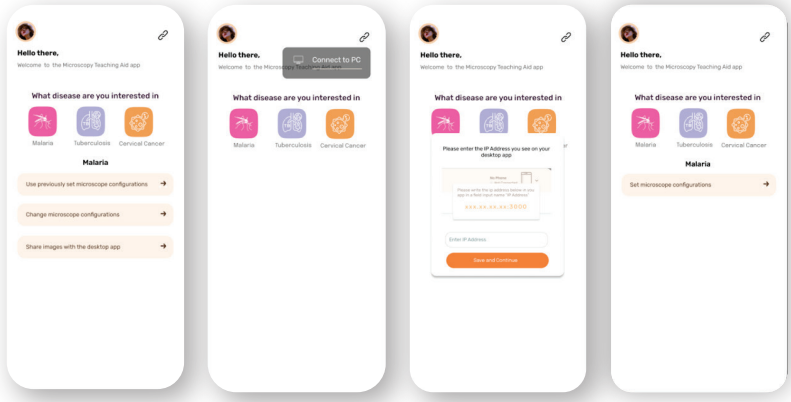
Data Collection App:

The data collection app systematically gathers microscopy images for both Malaria and Cervical Cancer. Along with the images, metadata such as blood slide details and microscope settings are recorded. This data is uploaded to a central server, creating a robust dataset to train AI models and further advance diagnostic tools.

Malaria Diagnosis App:

An Android app was created to assist with malaria diagnosis. Using AI-driven object detection, the app allows users to capture or upload microscopy images. The AI then processes these images, detecting and highlighting white blood cells and malaria trophozoites using bounding boxes streamlining critical data for analysis by healthcare professionals to determine a diagnosis





Microscopy Teaching Aid:

This is a desktop app that integrates with a mobile app to support microscopy education. Students capture images, which are uploaded with metadata for annotation and instructional feedback. This interactive platform enhances the learning experience, for both students and professionals in microscopy.

Project activities | Application testing

The application was tested both in-house and in the field at Kiruddu National Referral Hospital.

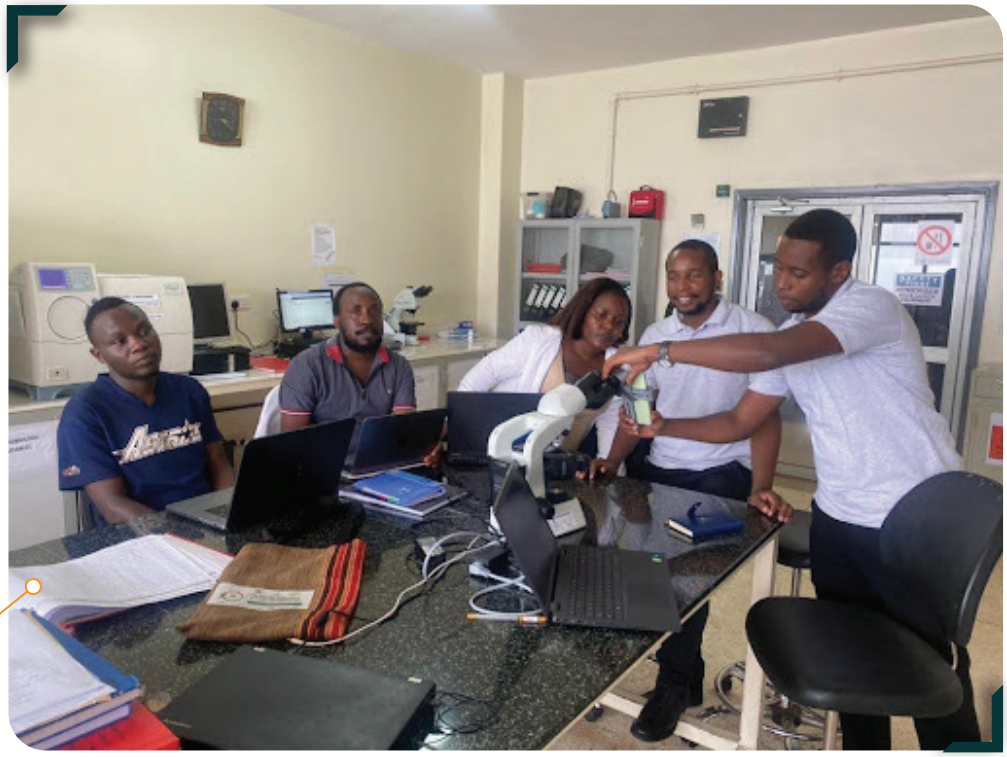
In-House Testing and Training:

During this session, an expert microscopist was trained on the full data collection process, simulating the entire workflow from slide preparation to microscope setup and image capture using the Ocular DC app. The microscopist provided valuable feedback, and several observations were made to guide improvements to the application.

Field Testing at Kiruddu National Referral Hospital:

The testing involved two expert microscopists who were trained on the Ocular DC app and included an evaluation of the 3D-printed adapter used to mount smartphones on microscopes. The test used two phone models (Samsung S8+ and Samsung A34) to assess how camera orientation affected the adapter's placement. The microscopists compared images captured by the Ocular DC app with those taken by the phones' native cameras. A key finding was the need for more picture frame aspect ratio options, which will guide future app updates

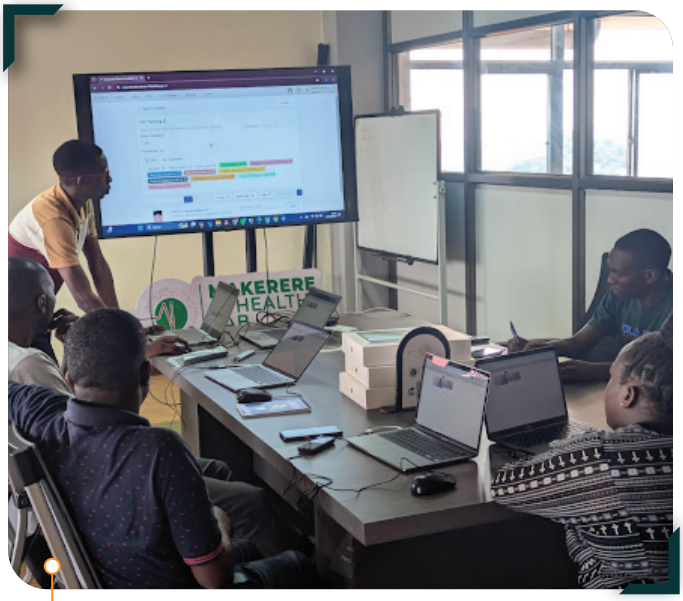
This round of testing has been instrumental in refining the Ocular DC application, ensuring it meets the needs of users in real-world healthcare settings.



Training the microscopist on how to set up the microscope for data capture

Project Activities | Data Collection and Annotation

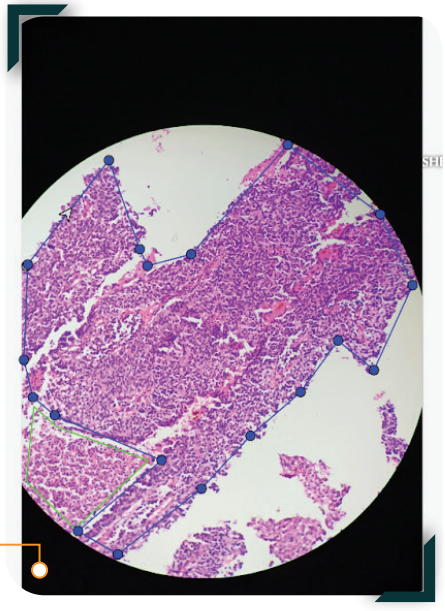
In June 2024, the project team initiated malaria data collection at Mulago and Kiruddu National Referral Hospitals (central region), Arua Regional Referral Hospital (north), Amudat District Hospital (east), and Kambuga District Hospital (west). Simultaneously, cancer data collection was conducted at the Uganda Cancer Institute Protocols for data collection and annotation were established to ensure consistent and machine-actionable datasets.



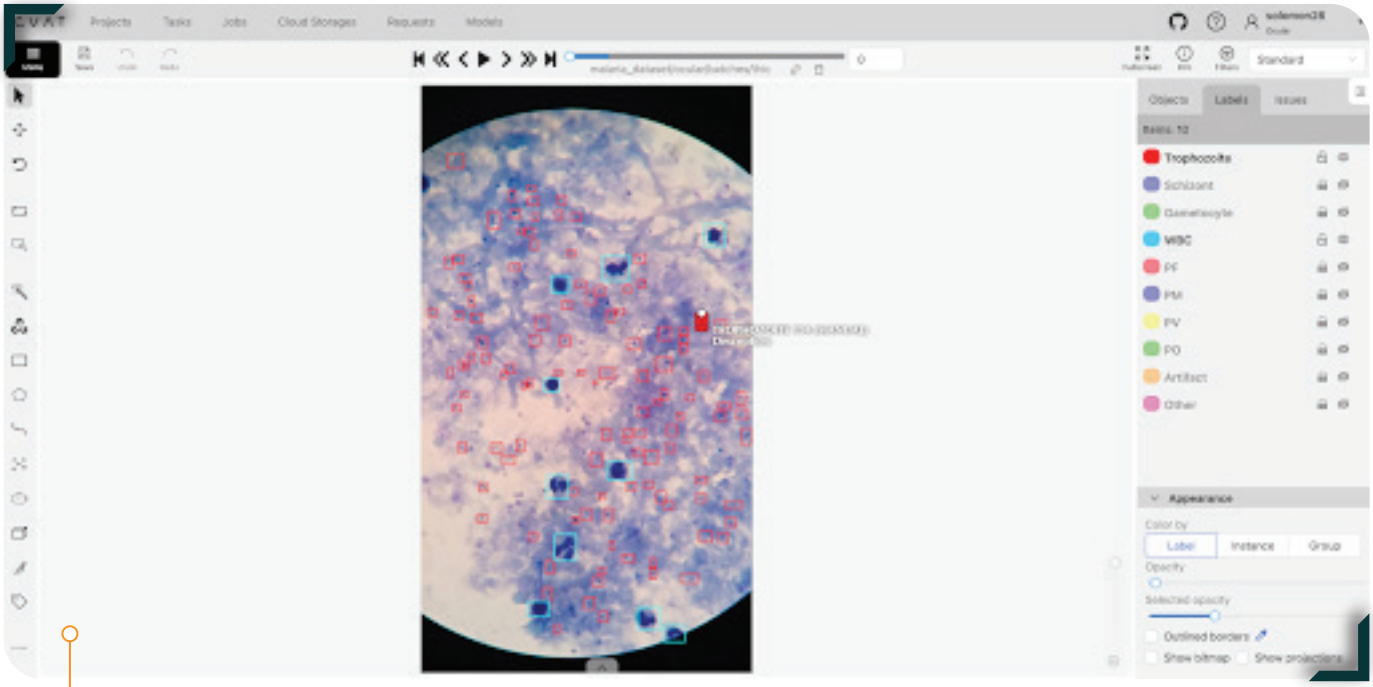
Data annotation training for UCI Pathologists

A comprehensive dataset of 5,966 cervical cancer images was collected, categorized into four classes:Normal, Precancerous, Cancerous (Adenocarcinoma), and Cancerous (Squamous Cell Carcinomas). Additionally, 195 cervical cancer diagnostic reports were gathered, with 88 used to train models for classification and report generation. Biopsy image annotation is ongoing, focusing on identifying key diagnostic features at various magnifications.

For malaria, a total of 6,044 images were collected from the selected hospitals across Uganda's key regions. These images were carefully annotated based on specific features, including species identification, growth stages of the parasite, and the presence of white blood cells, ensuring detailed and structured data for further analysis.



Sample annotated squamous cell carcinoma biopsy image

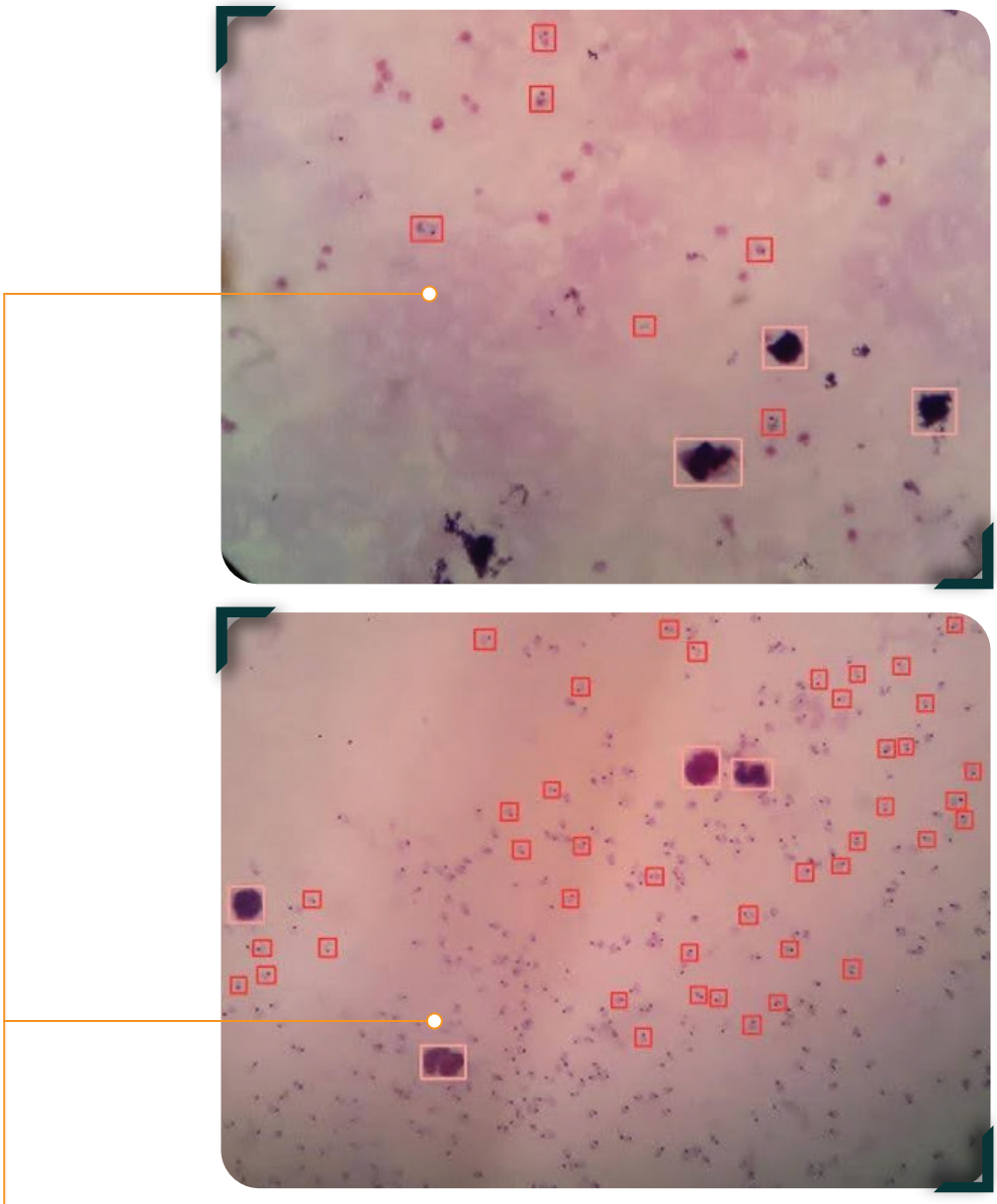


Sample annotated thick blood smear image

Project Activities | AI Model Development

Initial AI models for malaria diagnosis achieved a Mean Average Precision (mAP50) of 0.685 using YOLOv8.

These models were integrated into a mobile app for real-time diagnostics. Progress was also made toward developing AI models for cervical cancer diagnosis.
The cervical cancer classification models performed well, with DenseNet121 achieving 94% accuracy, followed by Inception (92%) and Xception (90%), effectively distinguishing between key cancer types. Report generation models, though based on a limited dataset, showed promise, with GPT-2 scoring a BLEU score of 0.34 and BioGPT scoring 0.21, indicating room for improvement as more data becomes available.

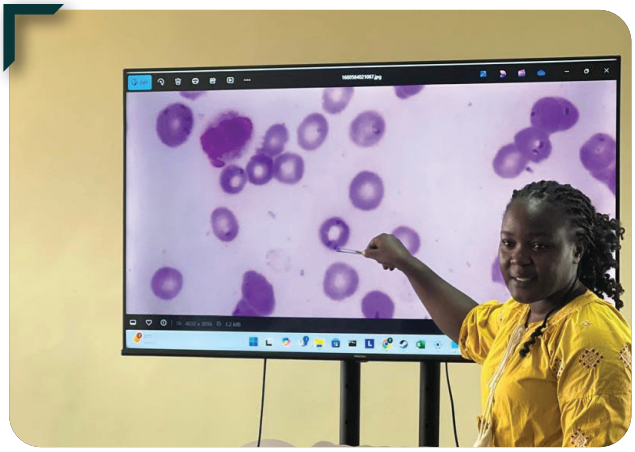


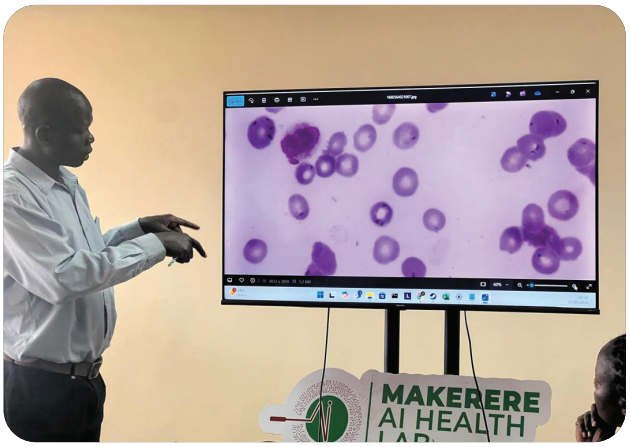
Sample detections of the YOLO Models

Project Activities | Training and Capacity Building

Comprehensive training sessions were conducted for medical technicians and pathologists to build capacity for using the OCULAR mobile app and 3D-printed adapters, critical tools for the deployment and use of the solution. These sessions focused on ensuring high-quality data collection and establishing a strong foundation for the broader deployment of the technology.

Approximately 150 technicians from three referral hospitals and two district hospitals were trained, with 25 technicians directly involved in malaria data collection. On the cancer front, 10 pathologists were trained, and four were actively engaged in data collection efforts. This training not only enhanced the participants' technical skills but also ensured a seamless integration of the Ocular tools into clinical workflows, accelerating the project's progress toward improving disease diagnosis.





Project Activities | Training and Capacity Building

Over the past year we created an opportunity within the project targeting Computer ScienceMasters, designed to build capacity in AI-driven health research. This initiative aims to provide aspiring researchers and students with hands-on experience in applying AI to critical healthcare challenges. By offering mentorship, training, and real-world problem-solving opportunities, the program will empower interns to develop valuable skills in AI and health analytics, fostering a new generation of innovators. Through this initiative, we are not only strengthening the project's impact but also contributing to the advancement of AI research in the healthcare sector.

Communication & Stakeholder Engagement

Communication & stakeholder Engagement | Media Exposure

Effective communication and stakeholder engagement have been essential to the success of the Ocular project. Over the past year, we utilized a multi-channel strategy, including media exposure, participation in high-profile events, and direct engagement with key stakeholders, to raise awareness and foster strategic partnerships.
These efforts have been critical in showcasing the project's potential and expanding its reach.

NTV's Health Focus featured Ocular's AI-powered diagnostic technology on Uganda's leading medical segment, reaching a broad audience of healthcare professionals and the public, which was essential for building awareness and trust in the technology;

Daily Monitor's Healthy Living spotlighted Dr. Rose Nakasi's pioneering work, showcasing Ocular's tool for diagnosing common diseases like malaria. This exposure was critical in demonstrating how the tool addresses urgent health challenges in Uganda;

Makerere University's "The Legacy" Newsletter presented Ocular's potential to alumni, many of whom are influential in the healthcare and policy sectors. This was key in garnering support and collaboration opportunities from within the academic and medical community;

New Vision and Words That Count further spotlighted the project, reaching national and international audiences;

Voice of Africa and Welt-sichten focused on the tool's ability to reduce patient wait times and tackle broader healthcare challenges in Africa, helping to position Ocular as a solution to pressing global health issues.

Communication & stakeholder Engagement | Participation in High-Profile Events

Ocular's participation in several high-profile national and international events played a pivotal role in increasing the project's visibility to different audiences and laying the groundwork for scaling the project both nationally and internationally. These events provided a platform to highlight the project's innovative AI-powered diagnostic solutions, directly engaging influential stakeholders in healthcare, technology, and policy.

National Science Week: Ocular showcased its AI-powered microscopy solution to key decision-makers within the Ugandan government and healthcare sector. This exposure was crucial in opening doors for collaboration, funding, and the potential for nationwide deployment, positioning the project as a cornerstone in the country's technological advancements;

CSPOC Conference: At this prestigious Commonwealth event, Ocular's innovation in democratizing healthcare access was a focal point. The presentation sparked interest from global stakeholders, highlighting the project's potential to transform diagnostics in underserved areas, and expanding Ocular's international reach;

IANPHI Conference: Dr. Rose Nakasi represented Ocular at this global public health forum, emphasizing the project's significant impact on disease diagnostics. This platform helped solidify Ocular's reputation as a leader in AI-driven healthcare innovations, attracting the attention of public health agencies worldwide,

National TB and Leprosy Summit: Addressing Uganda's critical need for improved TB diagnostics, Ocular presented its mobile microscopy solution as an effective tool for early detection. This was a key moment in aligning the project with national health priorities and reinforcing its role in combating infectious diseases and

World Malaria Day Colloquium and UGDev Summit: These events provided an opportunity to highlight the AI-powered diagnostic tool's potential in malaria diagnosis, a major health concern in Uganda.
Ocular's participation also underscored the broader implications of digital health innovation, cementing its place in Uganda's future healthcare strategies.

Communication & stakeholder Engagement |
Participation in High-Profile Events

Ocular's strategic engagement with healthcare professionals, institutions, and policymakers has been instrumental in validating the project's relevance and setting the stage for long-term collaborations. These interactions were essential for aligning the project with real-world healthcare challenges and ensuring its seamless integration into existing systems.

Nakaseke Hospital Visit: During this visit, the Ocular team gathered crucial feedback from frontline healthcare workers, which provided insights into the practical challenges faced in the field. This feedback was essential in refining the AI-powered diagnostic tool to better meet the needs of healthcare professionals working in resource-limited settings. By engaging directly with those using the technology, Ocular ensured its solution was not only innovative but also highly practical for day-to-day use.

Microscopists and Ministry of Health (MoH) Officials: Ocular demonstrated its AI-powered tool as a vital decision-support system for frontline workers. These presentations played a key role in strengthening the project's integration into Uganda's healthcare system, fostering greater trust and collaboration with the MoH. By engaging with policymakers and technical experts, Ocular positioned itself as a critical asset in enhancing diagnostic capabilities and supporting the country's broader public health goals.

Machine translation models for the medical domain: The project focused on developing machine translation models specifically for the medical domain, targeting English to Luganda translations. This initiative is vital for the healthcare community, as effective communication is essential for accurate diagnoses, particularly in the context of malaria and community engagement. Addressing language barriers can significantly enhance patient understanding, ensure proper treatment, and promote health literacy in underserved populations. The initial baseline MarianMT model, trained on the Makerere Corpus, achieved a BLEU score of 55%. While this score indicated a solid starting point, the model faced challenges with medical terminology and complex translations, which are critical in healthcare contexts where precision is paramount. To overcome these obstacles, the team implemented the MarianMT-Adapter LoRa model, enhanced through active learning techniques, resulting in a BLEU score of 56%.
This improvement signifies a reduction in translation errors and enhances the model's

ability to accurately handle domain-specific and culturally sensitive medical texts.
These engagements underscored the importance of collaboration with the healthcare community, ensuring that Ocular's tools are well-suited to local contexts and capable of delivering meaningful, long-term improvements in healthcare outcomes.

Strategic Collaborations

The project's efforts to secure permissions from the Ministry of Health, UCI and the IRB's over the past year have been vital for its success. By identifying key stakeholders and engaging in formal discussions, the team laid a strong foundation for collaboration. The preparation of comprehensive requests and documentation addressed data privacy and ethical considerations, ensuring compliance with national health regulations.
Consultative meetings facilitated open dialogue, allowing the team to gather valuable feedback and address concerns. Through collaboration with ethical review boards, the project met all ethical standards required for data handling. The successful acquisition of permissions from multiple health ministries aligned the project with national health priorities, while partnership agreements with health institutions fostered transparency and collaboration.
Ongoing communication with stakeholders has been crucial in building trust and reinforcing a commitment to ethical data practices. These collaborative efforts have enabled the project to access necessary health institutions and data, paving the way for improved disease diagnostics and healthcare outcomes. This foundation is essential for advancing the project's core activities and achieving its objectives.

Feedback on Project

The project and the solutions received strong support from the field medical teams who are the ultimate beneficiaries and some shared feedback with us.

The solution is great because the new technology doesn't strain the eyes like the traditional microscopy.

Denis Mukeba, Lab Technician Arua Regional Referral Hospital

Once approved by the relevant authorities the solution will come in handy to support us in making diagnosis and also taking into consideration the workload challenges, it will also help the district and the ministry on issues of human esource challenges.

Richard Ogwal, Agulurude Health Center III, Oyam District

It's not that complicated or hard to use. In malaria diagnosis examination you have to look at a specific number of fields but because this gives you a wider ield of view, it makes it easy to conclude without taking much time.

Opio Alfred Lab tech Arua Regional Referral hospital

I've seen the transformative impact of our work this year. Implementing our innovative adapter prototype, which integrates with our data collection app, enabled us to compile 5,966 high-quality histopathology images and 195 diagnosis reports. Overcoming technical challenges provided valuable insights into project management and problem-solving in resource-limited settings.

Lead researcher, Cervical Cancer Research Project | Uganda Cancer Institute

Feedback on Project

This experience deepened my understanding of cervical cancer pathology and underscored the critical importance of our research. Each dataset brings us closer to better diagnosis and treatment, potentially saving lives. Training pathologists has enhanced local research capacity, fostering collaboration and knowledge sharing. These achievements have strengthened my commitment to advancing cervical cancer research and improving healthcare outcomes in Uganda and beyond.

Wamozo Cosmas, MSc Computer Science Student

Through this project, where we are realising something that once seemed impossible - in that we can never truly know if something will work until we begin. This experience encourages me to dream about goals that challenge and scare me.

Eric Peter Wairagala MSc Computer Science Student

Project

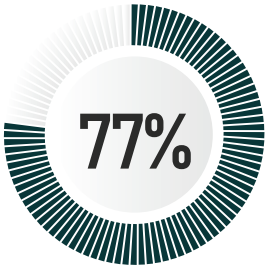
PERFORMANCE

OBJECTIVE 1:

Develop AI-based standardized approaches for deployable field microscopy diagnosis of malaria, tuberculosis, and cervical Cancer.

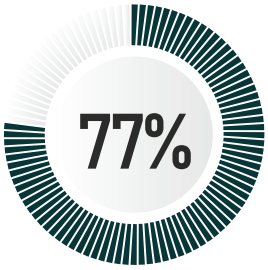
Hardware Fabrication

Designed, fabricated and field tested adapters for all the different types of microscopes



Data Collection

Data was collected to run AI models for malaria and cervical cancer. TB data collection awaits approvals



Application Development

Applications for data collection on malaria, cervical cancer, and tuberculosis were developed and tested, with the diagnosis app currently focused on malaria. Future updates will expand the app to include cervical cancer and tuberculosis models.

AI Model Development

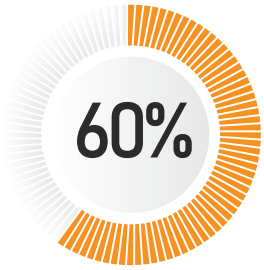
A model for detecting malaria parasites has been developed, while models for cervical cancer detection are currently in progress. Models for tuberculosis detection are pending the collection of TB data.

OBJECTIVE 2:

Build a complementary framework for surveillance

Requirements Gathering

Stakeholder engagements have been conducted to assess needs and define the initial system requirements for the complementary framework.



Conceptual Framework

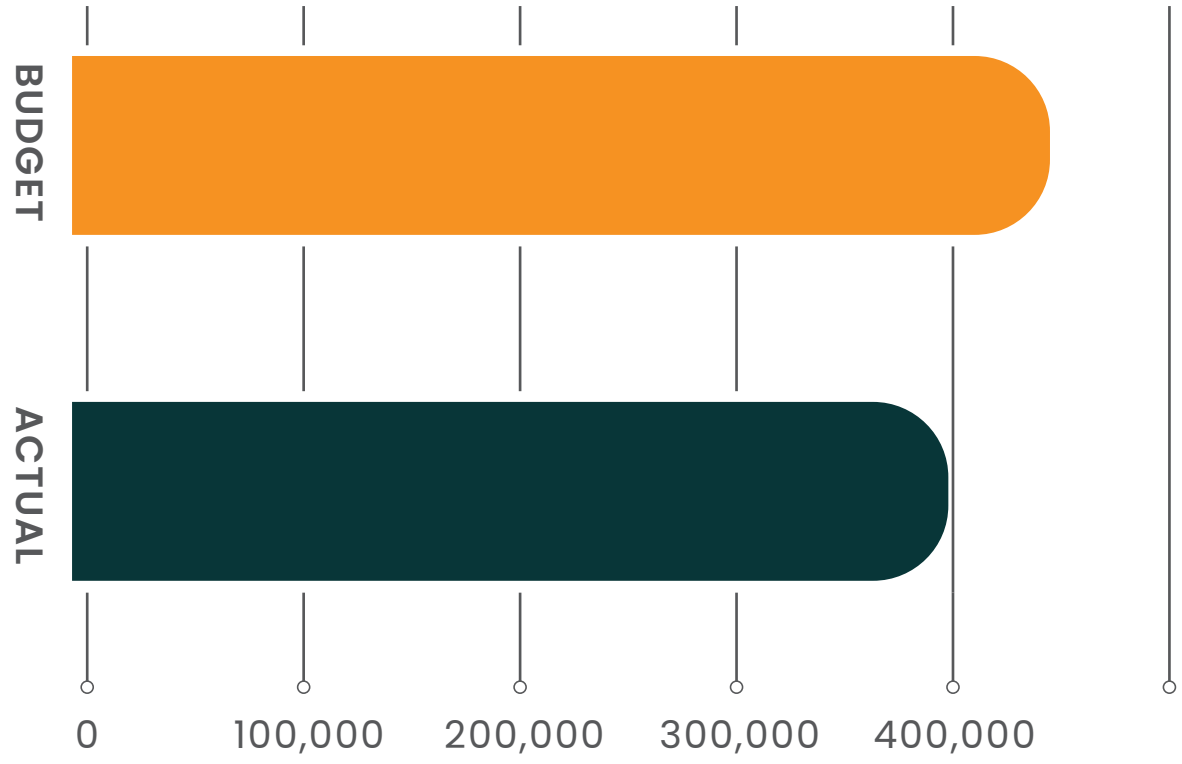
A prototype of the complementary framework has been developed and shared with stakeholders for feedback.

Project Performance | Budget & Financial Performance

This Annual Budget Performance Report provides an overview of Budget Execution from 1st October 2023 to 30th September 2024. It illustrates the performance of the grant in the first year.

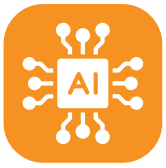
The Budget was anchored on the overall build strategy for a standardized point-of-care mobile microscopy for disease diagnosis with a specificity of up to 99%. The solution's current focus is on malaria, tuberculosis and cervical cancer but could be expanded to conditions such as intestinal parasites, sickle cells and anaemia.

The Total Budget for year one was USD 447,109 representing 30% of the overall three (3) year grant budget of USD 1,500,000. USD 414,323 was spent by the end of the year representing 93% of the annual (year one) budget.



Images

11,000 images collected to be used to train the model



Ai Model Performance

Malaria diagnosis model achieved mAP50 of 0.685; cervical cancer models reached **94%** accuracy.

Medical Personel

150 technicians and **10** pathologists trained on using the tool for malaria and cancer respectively

Health Facilities

6 health facilities involved in the project

11000	mAP50 of 0.685	94%	150	10	6
Images Collected	On malaria diagnosis	On Cervical Cancer Diagnosis Accuracy	Lab technicians trained	Pathologists trained	health facilities involved

Challenges & **Issues**

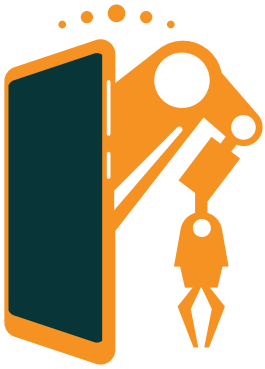
Approvals and Permissions

The TB IRB approval is still awaiting approval, which impacted the activities related to TB data collection, annotation and AI Model development. However we are engaged with the Mulago Research Ethics Committee (REC) and we expect to commence these activities in the coming year.

Hardware Production

The project encountered issues with 3D printers, which required frequent recalibration. Despite these challenges, fieldwork continued with minimal disruption.

Early testing revealed incompatibility between the adapters and certain microscope models. Rapid redesigns and re-fabrication resolved these issues, ensuring smooth data collection.



Cervical Cancer Detection and Report Generation

Mismatch between diagnostic reports and images, resulting in a significant reduction in the usable dataset. Only 88 out of 195 reports could be mapped correctly due to inconsistent slide naming conventions, leading to a 55% loss of data. Additionally, the limited amount of available report data hindered the full potential of the report generation models. The annotation process also encountered difficulties, particularly in categorizing images at different magnifications, which complicated the identification of regions of interest. Moving forward, addressing these challenges through rigorous quality control and standardised protocols is critical for maximizing the project's impact.

Risk Management

Risk Management

As artificial intelligence (AI) continues to advance and gain traction in healthcare, there is growing concern that AI technologies could replace certain roles, particularly those involving repetitive or data-driven tasks like diagnostics, medical imaging, and administrative duties. This raises the risk of job displacement in the health sector, particularly for workers whose tasks can be auttomated by AI systems. However, while AI has the potential to change the nature of certain jobs, it is important to recognize that it also creates new opportunities for enhancing healthcare delivery and workforce capabilities.

There are also ethical considerations that need to be taken into account in the development of this solution that include data privacy and confidentiality, bias and discrimination that may exacerbate health inequalities and the absence of a legal and regulatory framework which is outpaced by AI developments.

This can be mitigated by:

Re-skilling and Up-skilling the Workforce

Healthcare workers can be trained in using AI tools and technologies, ensuring they remain valuable contributors in an AI-powered environment. Continuous education programs should focus on developing skills in AI-driven data analysis, interpretation of AI outputs, and integrating AI into clinical practice.

Emphasizing Human-Centric Roles

Human health workers are irreplaceable regarding patient care, empathy, communication, and decision-making. Jobs that rely on these uniquely human qualities will remain critical. AI can take over routine tasks, allowing healthcare professionals to focus on more complex and patient-centered aspects of care, thus improving the quality of care provided.

Creating New Roles in AI Healthcare

The rise of AI will bring new job categories, such as AI ethics officers, AI system administrators, data analysts, and health data scientists. The development and maintenance of AI systems require skilled professionals who can oversee the deployment, monitoring, and ethical use of these technologies. Preparing the workforce to fill these roles can mitigate job displacement risks.

Implementing Ethical and Regulatory Frameworks

Governments and healthcare organizations need to adopt policies that ensure responsible AI adoption, including safeguards to prevent job loss without appropriate

re-skilling efforts. Ethical frameworks that encourage the use of AI to complement rather than replace healthcare workers should be prioritized.

Ensuring Equitable Access to AI Tools

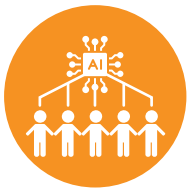
To prevent unequal distribution of AI benefits and risks, access to AI technologies should be democratized. This will ensure that AI adoption does not widen existing inequalities in the health workforce, and that both high- and low-resource settings can benefit from the new roles created by AI technologies.

Re-skilling and Up-skilling the Workforce

Emphasizing Human-Centric Roles

Creating New Roles in AI Healthcare

Implementing Ethical and Regulatory Frameworks



Ensuring Equitable Access to AI Tools

Future PLANS

TB Data Collection and AI Model Development:

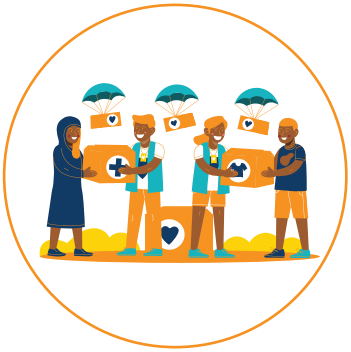
Data collection activities are expected to start in November 2024 once IRB approval has been secured.

Expanded Data Collection:

Further data collection will focus on tuberculosis and cervical cancer, along with continuous monitoring and improvement of the adapters.

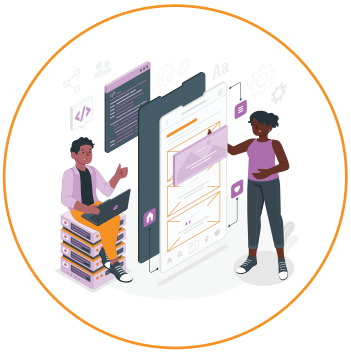
AI Model Optimization:

Work will continue on enhancing AI models for diagnostic accuracy, with a focus on tuberculosis and cervical cancer.



Scale-up Deployment:

The project plans to expand its tools to more health centers across Uganda, targeting remote areas to improve access to diagnostics.



App Development:

Iterative improvements to the mobile and desktop apps will be made based on user feedback, with new features to enhance diagnostic efficiency.

Conclusion

The first year of the Ocular Project has been marked by significant milestones in the journey to transform disease diagnostics in Uganda. Through the development of AI-powered microscopy tools, we have demonstrated the potential of this technology to improve diagnostic accuracy and healthcare outcomes, particularly in resource-limited settings. The project's success is a result of strong collaborations with healthcare institutions, support from the Ministry of Health, and engagement with frontline healthcare workers who have embraced this innovative approach.

Looking ahead, the Ocular Project is poised to expand its impact by optimizing AI models, continuing data collection, and scaling the deployment of tools. We aim to reach more regions and improve access to timely and accurate diagnostics. As the project moves into its next phase, we remain committed to addressing the critical healthcare challenges posed by malaria, TB, and cervical cancer, ensuring that these technologies continue to serve the people who need them most. Through ongoing partnerships and innovations, the Ocular Project will continue to push the boundaries of healthcare delivery in Uganda and beyond.

A Year in pictures

Ocular's first capacity building workshop

First in-field visit with Ugandan lab technicians Ocular demonstrating to lab technicians and Uganda's MOH officials.

Launch of the Makerere AI Health Lab

AI in Health discussion: Dr. Nakasi at Health Innovation (Online webinar on the Future of TB detection)

Training on Ocular's phone adapter

Ocular demo for Swedish journalist at Komamboga hospital.

Data collection training at Mulago Hospital.

Send off for our 5 interns that supported the project on various tasks of data analysis.

The Project

TEAM

Dr. Rose Nakasi
Principal Investigator

Michael Odwori
Project Accountant

Angida Franco Mugema
Co Project Accountant

Nsababera Linda
Project Manager

Dr. Andama Alfred
Chief Laboratory Technician

Bampangana Dora
Project Administrator

Nkunda Daphine
Project Communications & Lead Public Relations

Jane Anyango
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Aliba Leah
Lead Research Assistant

Mubiru Byron
Research Assistant

Naisanga Edith
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Mutebi Chodrine
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Steven Kasumba
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Wadda Vincent
Microscopy Data Expert - Malaria

Henry Mutegeki
Data Scientist

Wamozo Cosmas
Masters of Science in computer science student

Eric Peter Wairagala
Masters of Science in computer science student

Acknowledgements

We would like to express our sincere gratitude to all individuals and organizations that have contributed to the success of the Ocular project throughout the past year.
First and foremost, we extend our heartfelt thanks to the healthcare professionals, technicians, and pathologists who dedicated their time and expertise to train and implement our innovative AI-powered diagnostic tools. Your invaluable feedback and support have been instrumental in refining our solutions and ensuring their relevance in real-world settings.

We also wish to acknowledge the collaboration and guidance provided by the Ministry of Health, Mulago Hospital Research and Ethics Committee, and the Uganda Cancer Institute Research Ethics and Committee. Your support in facilitating access to health data and institutions has been crucial in advancing our project goals.
Special thanks go to our partners at the Uganda Cancer Institute, Kiruddu and Mulago National Referral Hospitals, Arua Regional Referral Hospital, Nakaseke Hospital and Amudat and Kambuga District Hospitals for your commitment to enhancing disease diagnostics in Uganda. Your collaboration has significantly enriched our efforts and expanded our reach within the healthcare community.

We are grateful for the contributions of our technical and administrative teams, whose hard work and dedication have propelled the project forward. Your tireless efforts in research, development, and data management have been vital to our success.
Finally, we would like to thank the funder, Google, ; whose financial support has made this project possible. Your investment in our vision reinforces our commitment to improving healthcare outcomes in Uganda and beyond.
Together, we look forward to continuing our collaborative efforts to innovate and enhance disease diagnostics, ultimately contributing to better health outcomes for all.

THE END

OCULAR PROJECT ANNUAL REPORT 2024

MAKERERE UNIVERSITY

OCULAR

AUTOMATING MICROSCOPY