

# Design of Glaucoma Optic Neuropathy Risk Monitoring System Based on Integrated Object Detection Machine Learning Eye Biometry Model

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**Abstract:** Glaucoma optic neuropathy (GON) is a glaucoma complication that has become the second most common cause of blindness in the world. This condition occurs due to an uncontrolled increase in intraocular pressure. Current GON risk monitoring still requires direct contact with the eyes (invasive) and is only available in healthcare centers, so patients are prone to drop out of therapy. A GON risk assessment system that fulfills eye care device standards is needed. Glaucoma Assist (Glassist), a monitoring assistant system based on a biometry model and machine learning integration, was developed as a GON risk monitoring tool. It is inspired by a hollow sphere diameter that will increase with its pressure. It is also directly proportional to the biometric model of axial length changes. This concept is integrated with object detection machine learning and displays the GON risk interpretation on a website. Glassist and iCare tonometer showed a matched result with the error of  $0 \pm 0.8$  mmHg, which fulfills the allowable tolerance by ISO 8612:2009. Glassist's features are easy to use, showing an overall success rate of 86%. The system usability scale test indicates that Glassist can function well and is accepted by the users with a final score of 82%. Glassist has fulfilled eye care device standards and is highly potent for commercialization.

**Keywords:** Axial length, Biometry, Glaucomatous optic neuropathy, Machine learning.

## Introduction

Glaucoma optic neuropathy (GON) is a visual impairment caused by uncontrolled increased pressure inside the eyeball or intraocular pressure (IOP). GON begins with a disruption in the aqueous humor flow system, resulting in fluid accumulation in the eyeball, which results in increased IOP. In 2020, an estimated 80 million people worldwide were at high risk of blindness due to GON [12]. This disorder has even attracted the attention of the World Health Organization and government health institutions in the Vision 2020 Program, which addresses the most common causes of blindness [18]. If not treated immediately, increased IOP above normal values (14-20 mmHg) can cause pressure on the optic nerve. The progression from glaucoma to "On" causes symptoms such as loss of visual field, changes in color perception, and decreased pupillary reflexes. If not treated properly, patients can experience permanent blindness. Therefore, monitoring IOP and clinical symptoms is important to prevent GON.

GON risk monitoring is usually done by assessing IOP using a standardized tonometer. Health workers with special skills must carry out measurements with a tonometer, so patients must regularly visit health facilities. Current glaucoma monitoring methods still require direct contact with the patient's eyeball (invasive), which causes discomfort in routine use [16]. Most of these tools cannot yet perform GON risk assessment automatically, so the analysis of clinical manifestations of the disease is completely carried out by doctors [14]. These conditions make glaucoma patients vulnerable to therapy discontinuation (loss-to-follow-up) [4]. In addition, health services to monitor GON risk can only be accessed by patients once a month. Changes in IOP values in patients can occur in a weekly period so GON risk assessment should be carried out earlier [11].

Referring to the problems experienced by GON patients, a system is needed that can help patients monitor the risk of GON without requiring direct medical assistance (self-monitoring). This system must meet the standard indicators of eye health devices. Following the international standard ISO 15004-1, the system must be accurate and as non-invasive as possible [17]. To support the self-monitoring function, the system must be able to be operated simply, be portable [20] and be cost-efficient [3, 20]. Thus, the Glaucoma Assist (Glassist) prototype, as a machine learning-based monitoring assistant system, is present as an effective solution to the challenges of these problems. The working concept of Glassist is inspired by changes in fluid pressure in a hollow ball that is proportional to changes in the diameter of the ball. Similar to the eye, an increase in IOP will also be accompanied by an increase in the axial length (AL) of the eyeball. Studies show that there is a significant relationship between changes in IOP and changes in AL [8]. Therefore, increased IOP as one of the parameters for assessing the risk of glaucomatous optic neuropathy can be determined based on the AL biometry approach. Glassist only requires input in the form of a side-view image of the outer eyeball to determine IOP. This is certainly much more comfortable for patients because it does not require direct contact with the eyeball. In addition, Glassist is integrated with machine learning that can display an analysis of the side-view biometry model of the outer eyeball, interpretation of GON risk based on changes in IOP values, and the patient's disease development history. This system is also loaded in the form of a website so that it can be accessed by users on various types of devices.

## Materials and methods

In developing GON risk monitoring system that meets the standard indicators of eye health devices, an approach is taken with AL dimension analysis that can be obtained from the side view of the outer eyeball. The structure of the eyeball is analogous to a ball shape containing incompressible fluid, with the sclera and cornea as the outer layers and aqueous humor as the fluid. An illustration of the structure of the eyeball can be observed in Fig. 1.

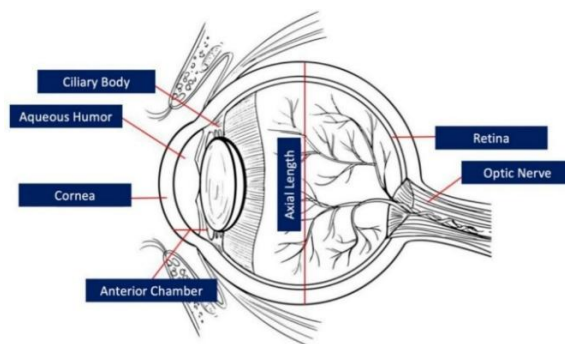


Fig. 1 Illustration of the structure of the eyeball

This approach can be supported by the implementation of object detection, one of the machine learning methods that can provide interpretation of the position (localization) and type (classification) of an object [1]. This method allows the direct acquisition of the eyeball biometric model. Several parameters are used to obtain the AL, as the geometric relationship of all parameters is shown in Fig. 2.

Based on the eye biometry approach in Fig. 2, the circumference of the cornea and sclera can be modeled as two circles. The intersection point of the two circles is representative of the distances  $X$ ,  $Y$ , and  $A$ , which can be used as a rectangular plane. The relationship between  $X$ ,  $Y$ ,  $A$ , and axial length is shown in Eqs. (1) and (2). Further interpretation for changes in IOP ( $\Delta IOP$ ) is shown by eq. (3) as a linear correlation model between IOP and AL, with  $k$  being the coefficient and  $a$  being the constant to be obtained from testing the device [7].

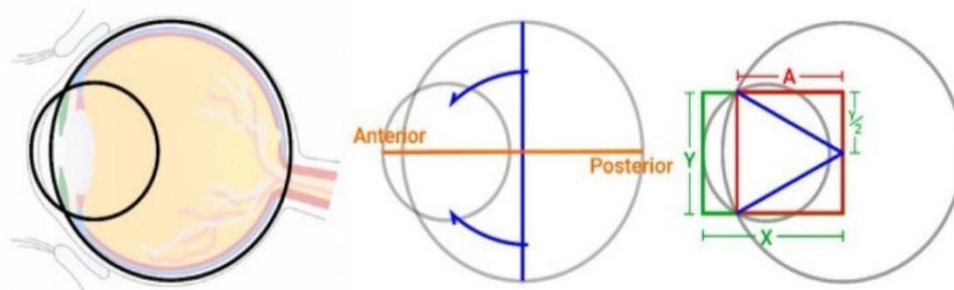


Fig. 2 Glassist eye biometric measurement approach

$$\left(\frac{AL}{2}\right)^2 = \left(\frac{Y}{2}\right)^2 + (A)^2 \tag{1}$$

$$AL = 2\sqrt{\left(\frac{Y}{2}\right)^2 + (A)^2} \tag{2}$$

$$\Delta IOP = k \cdot AL + a \tag{3}$$

The design and realization of the monitoring assistant system for GON risk based on an integrated machine learning biometric model was carried out in three main stages as shown in Fig. 3.

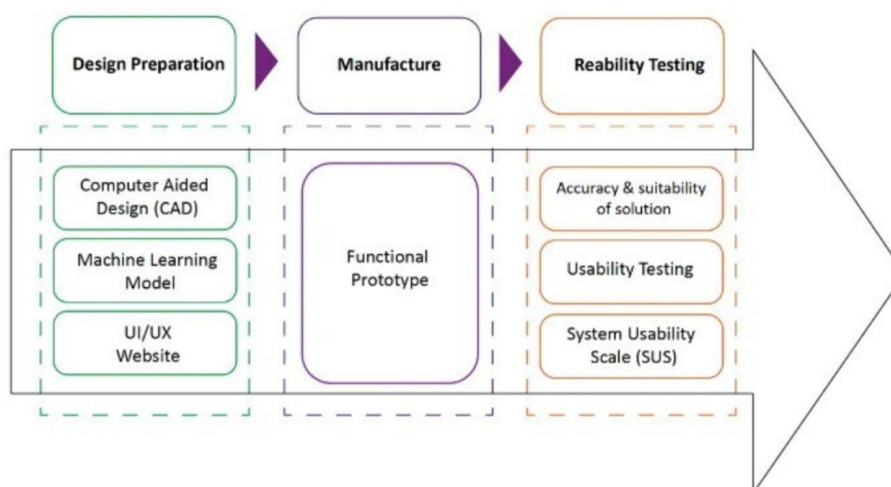


Fig. 3 Design and realization stages of the Glassist prototype

### Physical design and control design of Glassist prototype

As an initial stage, the design preparation is carried out as a guideline for the implementation of the manufacturing stage. The design planning includes computational aided design (CAD) and the architectural design of the object detection machine learning (ODML) model to be used in the Glassist prototype.

The CAD process was carried out using SOLIDWORK 2017 software. Reviewing the shooting plan and Glassist functionality for side-view eye detection (Fig. 4), the Glassist prototype CAD was made with two main parts, namely the headrest and the control box. The headrest is a component that helps users to adjust the camera position and standardize the distance of the side-view eye image capture results.

In designing the Glassist ODML model, a transfer learning method was used with the pre-trained EfficientDet D2 network, following the state-of-the-art object detection and its capabilities to detect objects with the fewest parameters from other detector models without reducing their accuracy [13]. EfficientDet D2 is an object detection model architecture designed to achieve a balance between efficiency and accuracy. It is part of the EfficientDet family, built on the EfficientNet backbone, utilizing compound scaling techniques that balance input resolution, backbone network, and detection features. In object detection, including for small and specific objects such as eyeballs, EfficientDet D2 works by utilizing the bidirectional feature pyramid network (BiFPN), which allows for the efficient aggregation of information from various feature levels. BiFPN helps the model to be more effective in detecting objects with varying scales, which is very important in eyeball detection, where the object size may be small and the details are complex. In addition, this architecture uses a weighted feature fusion technique that ensures that the contribution of each feature layer is increased as needed, resulting in more accurate predictions with reduced noise in detection. The EfficientDet architecture can be observed in Fig. 4.

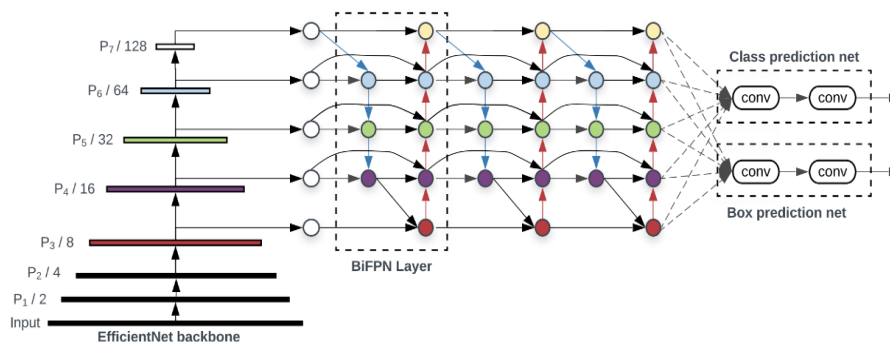


Fig. 4 ODML architecture with EfficientDet which is an inheritance of the EfficientNet pre-trained network with a combination of BiFPN

To support the model design, the dataset was obtained by directly collecting side-view eye images using a prototype camera setup according to the design. The model can later be trained at the same image quality and size when launched (deployment). The dataset obtained was 951 images, consisting of 943 side-view images of the outer eyeball. As a strategy to evaluate the model, a number of these datasets were split with a ratio of 80:20 so that they could be evaluated directly for the development of the Glassist ODML model. The design of the ODML Glassist model was carried out using the open-source TensorFlow framework on the Google Colab platform, which provides access to use graphics processing units to speed up the training process without the need for configuration [15]. The training of the ODML Glassist

model was conducted over 100 epochs, with early stopping at the 20th epoch to prevent model overfitting, followed by model testing. This stage produces training metrics and testing metrics, which are used as indicators of the model's capability in determining the side-view eye object and its dimensions. Some of the metrics used are cross-entropy loss (to see the magnitude of the error in the object prediction results with the actual data), box loss (to see how well it determines the center point of the object and how well the bounding box prediction covers the object), overall mean average precision (mAP), at a threshold of 50% (AP50) and a threshold of 75% (AP75) (to see the precision of the ODML model) with a threshold value of 0.8 to be said to have been able to detect well [10]. After the training is complete, the model can analyze the eye biometry model which is then installed on a Raspberry Pi mini-computer with a simple configuration and according to the target capabilities of Glassist.

Glassist is also designed to support ease of use, so an interface is needed. The website interface is chosen to allow users to access the latest IOP monitoring results and GON risk interpretation. To be accessible on various devices, Glassist requires an information system that can send ODML data to a cloud database. Firebase is the optimal choice considering its advantages in the application programming interface that is easy to apply to Raspberry Pi and the website. Thus, the Glassist website can become a tool to facilitate users in operating Glassist without requiring special skills.

The Glassist website design is designed with a user interface that includes several supporting features for use, such as the check feature, examination history feature, and clinical biodata feature. The Glassist user interface is designed to be fully integrated with the tool through the Google Cloud Platform.

### *Glassist prototype manufacturing*

The manufacturing stage is carried out to obtain functionality according to the objectives by referring to the results of computer-aided design, ODML models, and user interfaces. At the manufacturing stage, the implementation process is carried out through three-dimensional printing of physical prototypes. The physical prototype is then integrated with the automation system components and user interface that have been created [6].

At the physical prototype printing stage, the additive manufacturing 3D printing (AM-3DP) method is implemented based on the results of computer-aided design. AM-3DP is used by reviewing the cost efficiency and complexity of the resulting geometry. This is noteworthy considering that the physical design of Glassist requires relatively high geometric accuracy. As the main material in AM-3DP, polylactic acid is used, which has a flexural strength of 106 MPa, so that it has exceeded the structural needs of Glassist [5].

The control system manufacturing is carried out by assembling the Glassist ODML components, which include: Raspberry Pi processor board, Raspberry Pi camera module, and resource system. In the image capture system, the Raspberry Camera Module V2 has a specification of 3280×2464 pixels that can be used to view side-view images. The power source used is a Li-Ion 18 650 battery arranged in series with a step-down component to obtain a voltage that suits the needs of the Raspberry Pi. Other supporting components in the form of buttons, cables, and LEDs are useful for providing control over lighting so that it can improve the quality of the images taken.

### Prototype functionality testing

The dataset preparation was carried out to develop a machine learning model in the next design stage. The dataset was manually collected in a previous study, which obtained a dataset of 224 side-view eye images at Prof. Dr. I.G.N.G Ngoerah General Hospital, Denpasar, Bali, Indonesia. The dataset collection process was carried out manually by capturing side-view eye images, as shown in Fig. 5A, using a camera installed on the prototype, as depicted in Fig. 5B. The criteria for the dataset taken included healthy research participants with a minimum age of 21 years, which aimed to standardize the characteristics of the adult eyeball. In this study, the entire dataset will be divided into three categories: training, testing, and validation datasets.



Fig. 5 Side view eye dataset (A) and illustration of dataset collection (B)

In evaluating the functionality of the prototype, several tests were carried out to meet the indicators required by the Glassist prototype. The tests carried out consisted of solution suitability testing, usability testing, and the system usability scale (SUS).

The solution suitability test was intended to determine the level of suitability of the Glassist prototype output in the form of the AL of the eyeball and IOP, and their correlation. All solution suitability tests were carried out at Prof. Dr. I.G.N.G Ngoerah General Hospital, Bali, Indonesia. The test subjects were glaucoma patients registered in the eye polyclinic register of Prof. Dr. I.G.N.G Ngoerah General Hospital, Bali, Indonesia. One patient underwent two Glassist measurements with a gap between measurements of one week. The correlation test between changes in AL by Glassist measurements and IOP values (measured with an iCare tonometer) was carried out as an initial validation of the Glassist measurement. If the correlation test shows a weak correlation ( $r < 0.6$ ), the placement of the slider component needs to be reset. If a strong correlation is obtained ( $r \geq 0.6$ ), the test is continued by calculating the error against the tools commonly used in medical service centers. This test compares the Glassist prototype in two parameters, namely: AL dimension (which is compared to the NIDEK Echoscans US 4000 eye biometry tool); and IOP (which is compared to the iCare tonometer tool). The results of the comparison of the Glassist prototype with the two measuring instruments are in the form of the average error and its standard deviation. These values are parameters related to the accuracy and precision of Glassist measurements. All testing procedures involving patients have obtained ethical eligibility statements № 1835 / UN14.2.2.VII.14 / LT / 2022 from the Ethics commission of the Faculty of Medicine, Udayana University, Bali, Indonesia. The hospital's ethical program committee approved the trial of the Glassist monitoring device due to several factors, such as its non-invasive nature, direct eyeball measurements without using existing data, and the patient's consent. The testing stage is continued with usability testing to assess the ease of use of the features on the Glassist website. Users are assigned to access and use the features of the Glassist website according to the instructions for using the tool according to the instructions. After that, the assessment is carried out in the form of scoring and review if there is a feature mismatch. Instructions that must be followed by users include: signing up, logging in, filling in personal data, accessing how to use it, checking the last IOP value, and checking the examination history. The usability testing score is assessed based on the successful rate (SR) for each instruction, which is the percentage of the total number of

respondents' scores per maximum score that can be obtained. The SR score is then averaged to obtain an overall successful rate (OSR) which describes the level of user success in accessing and using the Glassist website features without assistance. If the prototype's OSR value has met the threshold value ( $OSR \geq 80$ ), the prototype can be declared easy to use by users. The SUS assessment was also carried out to assess the overall functionality of Glassist. SUS assesses user opinions regarding the concept, convenience, and benefits of Glassist. The assessment was carried out using a standardized questionnaire that has been proven to be valid and reliable. This questionnaire consists of five positive questions and five negative questions. Each question has an answer with a five-point scale (strongly disagree, disagree, neutral, agree, and strongly agree). The final score of the SUS questionnaire is a single score from 0 to 100 with an interpretation in the form of a standardized adjective rating scale as shown in Fig. 6 [2].

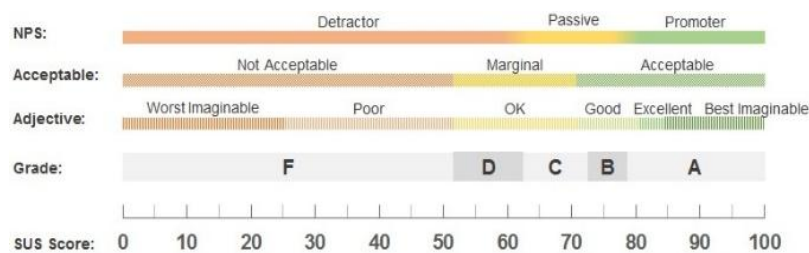


Fig. 6 Adjective rating scale for SUS [2]

## Results and discussion

### *Glassist ODML model*

ODML model used in the Glassist prototype is a transfer learning model derived from the pre-trained EfficientDet V2 network. Glassist ODML model was trained with 20 epochs, with loss metrics for each epoch shown in Fig. 7. Description of the training and testing metrics of Glassist ODML in the form of box loss and cross-entropy loss. The graph trend shows a decrease in the loss value at each epoch. These results indicate that the ODML algorithm can learn (trainable) on the dataset provided to produce side-view eye object output and its dimensions as a biometric model.

The relationship between epochs and evaluation metrics shows that early epochs (0.0-5.0) have the greatest impact in reducing loss and increasing mAP, while intermediate epochs (3.0-12.5) still provide improvements but at a slower rate. In the final epoch (12.5-20.0), the model reaches stability where the addition of epochs does not provide significant improvements. These results indicate that the model is capable of object detection in 20 epochs of training. These results indicate that the EfficientDet D2 architecture is capable of learning (trainable) on the side view eyeball dataset to produce side view eye object output and its dimensions (bounding box) as a model of eye geometry.

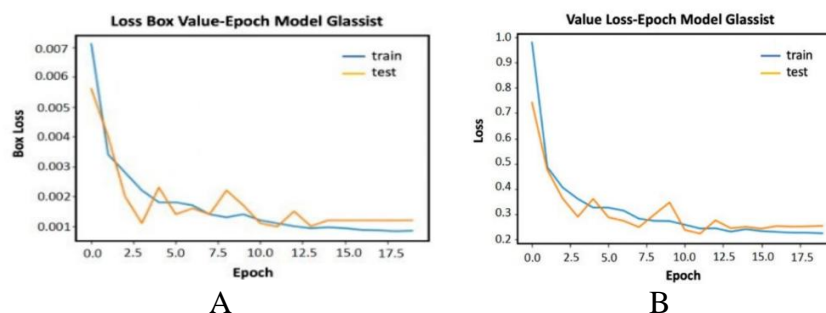


Fig. 7 Metrics graph: box loss (A) and loss per epoch during the training process (B)

The complete metrics values on cross-entropy loss, box loss, and mAP at 50% threshold (AP50) and 75% threshold (AP75) for the Glassist ODML model are shown in Table 1. The mAP value of 0.83 indicates that the Glassist ODML model has good performance (mAP > 0.8). Based on these parameters, the Glassist ODML model has shown good performance.

Table 1. ODML metrics evaluation

Cross-entropy loss	Box loss	mAP	AP50	AP75
0.03	0.00	0.83	1.00	0.99

### *Glassist functional prototype*

Referring to the results of the physical design and control system, a manufacturing process was carried out with the results in the form of a functional prototype with general specifications listed in Table 2.

Table 2. General specifications of the Glassist prototype

General		Head Support		Control Box	
Characteristic	Value, Unit	Characteristic	Value, Unit	Characteristic	Value, Unit
Width	170 mm	Width	145 mm	Width	115 mm
Length	280 mm	Length	223 mm	Length	155 mm
High	160 mm	High	94 mm	High	82 mm
Mass	519.84 gram	Mass	158.46 g	Mass	361.38 gram
Power	15 W			Camera	8 MP
Input voltage	5 V (DC)			LED	1 W
Input current	3 A				

Overall, the prototype has been able to provide an interpretation of the risk of glaucomatous GON based on changes in AL that are directly related to changes in IOP. The working process of the tool begins by providing power to the Raspberry Pi board and camera module. Furthermore, the system is automatically able to connect to the internet. Fig. 8 is a schematic diagram of the results of the machine learning control system arrangement and the overall flow of Glassist usage. To use Glassist, users need to register an account on the website <https://glaucoma-assist.com> via the “Sign Up” menu. Users are required to fill in their biodata and medical history via the “Fill in Biodata” menu. The patient’s last AL and IOP values will also be input into the system as a guide for Glassist in determining the current IOP value and GON risk. Users can access the “How to Use” menu to get a guide to operating Glassist.

IOP progression is typically monitored in patients at risk for or diagnosed with glaucoma, as increased IOP can damage the optic nerve. Monitoring of IOP progression will display improvement or worsening on the LCD screen.

The meaning of improvement or worsening based on the results of the IOP progression analysis is as follows: Glaucoma monitoring is considered improved if the IOP shows a decrease or stabilization within the normal target range (usually 10-21 mmHg, depending on the case) and there is no significant upward trend over time. Conversely, glaucoma monitoring is considered worsening if the IOP progressively increases or fluctuates significantly despite therapy, and the IOP frequently exceeds the allowable target.

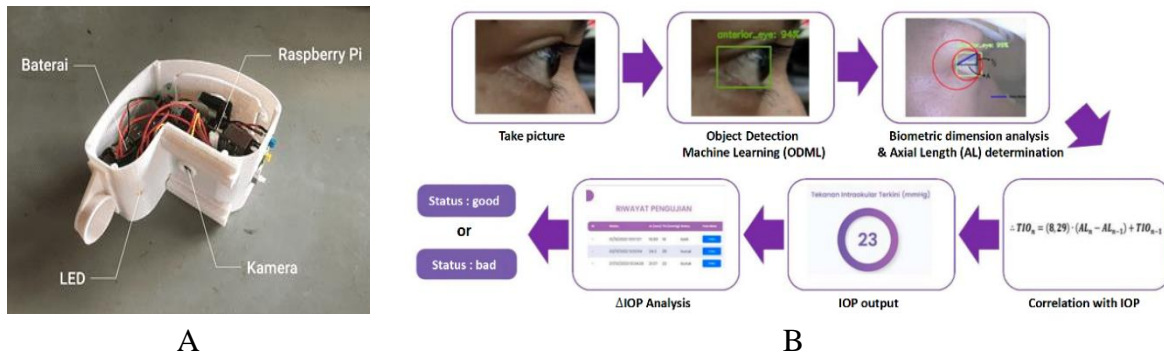


Fig. 8 Glassist functional prototype: (A) control system layout; and (B) Glassist usage flow.

To perform the examination, the user accesses the “Check” menu on the website. The user fits the Glassist on the head according to the instructions in the user manual. The user presses the capture button, and then the Glassist automatically takes a side view of the outer eyeball. The image will be analyzed by ODML to obtain the appropriate biometric model and AL dimensions. The AL dimensions will also be interpreted into representative IOP values according to the model test results. The analysis output by Glassist ODML model is then sent to the cloud. The current IOP value and interpretation of the risk of GON will be displayed directly on the “Check” menu. Users can also access the history of examination results on the “History” menu.

### *Glassist prototype functionality*

The test subjects included in the solution suitability test were 30 people. Fig. 9 shows the correlation test between the iCare tonometer IOP data and the Glassist AL, which showed a strong positive correlation ( $r = 0.84$ ). Scattering correlation diagram showing how changes in IOP relate to changes in AL, based on measurements of the Glassist prototype. If the dots show an upward trend ( $\Delta AL$  increases as  $\Delta IOP$  increases), it’s called a positive correlation, as in Fig. 9. However, if the dots show a downward trend ( $\Delta IOP$  increases but  $\Delta AL$  decreases), it’s called a negative correlation. And finally, if the dots are randomly distributed, it’s called a weak or no correlation. This indicates that the IOP value issued by Glassist is representative of the IOP value from the tonometer at Prof. Dr. I.G.N.G Ngoerah General Hospital, Bali, Indonesia.

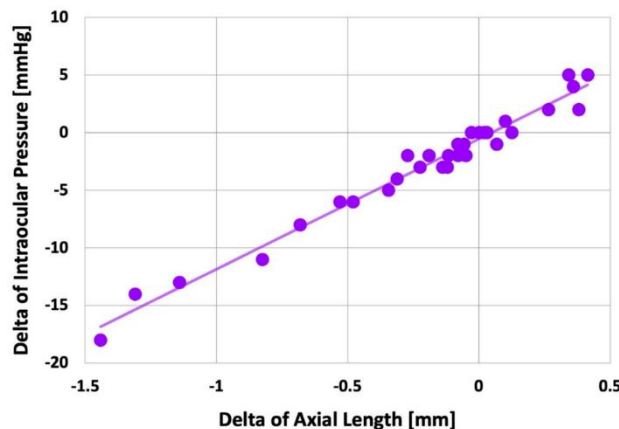


Fig. 9 Correlation scatter diagram of IOP changes and AL changes of the Glassist prototype

The average value and standard deviation of the error calculation between the Glassist measurement results and the measuring instrument at Prof. Dr. I.G.N.G Ngoerah General Hospital, Bali, Indonesia are shown in Table 3. From the results of the IOP comparison, the average error value of 0 mmHg indicates that the Glassist measurement results are accurate with the tonometer measurement results [5]. The standard deviation error of 0.8 mmHg, which is below 5 mmHg as the standard tonometer tolerance limit, indicates that Glassist meets the precision standards as a tonometer [19].

Table 3. Results of the average value and standard deviation error of the Glassist prototype with measuring instruments at Prof. Dr. I. G. N. G. Ngoerah General Hospital, Bali, Indonesia

Parameter	Mean $\pm$ standard of error deviation	Comparison device
Axial length	0.03 $\pm$ 0.02 mm	NIDEK Echosan US 4000
Intraocular pressure	0 $\pm$ 0.8 mmHg	iCare

Usability testing and SUS tests have subjects with an age distribution of 18-61 years. Usability testing shows respondents can complete instructions independently with an OSR of 86.11% and have met the threshold value. The interface features on the Glassist website can be declared easy to use by users. The results of the usability testing are presented in Table 4.

Table 4. Usability testing results, where *a* is successful rate and *b* is overall successful rate

Parameter	Score					
	Sign up	Login	Fill of biodata	Access how to use	Check TIO	Check history
SR <sup>a</sup>	85.7	84.5	86.9	77.4	88.1	94.1
OSR <sup>b</sup>	86.1					

The SUS test results showed a final score of 82. According to the SUS interpretation scale, this score has met the criteria of excellent and acceptable. Therefore, the Glassist website has functioned well and can be accepted by users. As a comparison between similar products and Glassist, Table 5 shows the standard indicators of self-monitoring-based eye health devices that have been adapted from international standard associations.

All functional tests show that the concept of measuring with a side view of the outer eyeball, integration of ODML, and Glassist website features are capable of becoming a GON risk monitoring system that supports patient self-monitoring. Glassist prototype maintenance can also be said to be quite intuitive, namely, only needing to be recharged when the light indicator is not on (battery power is empty). Therefore, the development of this prototype has been able to meet six indicators for eye health devices as GON risk self-monitoring.

## Conclusion

Based on the results obtained, it is concluded that the Glassist glaucoma optic neuropathy risk monitoring system has met the standards for eye health devices as a non-invasive, cost-efficient, portable, accurate self-monitoring tool that can be used without the assistance of medical personnel. The Glassist prototype can be developed through clinical trial stages, obtaining distribution permits, and production permits so that it is ready to be commercialized.

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**Prof. Ir. I. Wayan Widhiada, Ph.D.**

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Prof. I Widhiada, S.T., M.Sc., Ph.D., graduated with his B.Sc. degree in 1994. He then continued his M.Sc. degree program at Liverpool John Moores University, England, supported by a scholarship from the Indonesian government and graduating in 2000. In 2008, he returned to Liverpool John Moores University to pursue his doctoral studies, focusing on automatic control systems and robotics, which he completed in October 2012. Since 2013, he has conducted extensive research in automatic control systems, specifically robotics, baby incubators, segways, drones, and medical devices. In April 2021, he was appointed as a Permanent Professor in the Faculty of Engineering at Udayana University, Bali, Indonesia. Throughout his career, he has supervised many graduate students and collaborated with industry partners to solve real-world engineering challenges. Prof. Widhiada is a member of professional organizations, such as the Indonesian Mechanical Engineers Association, and has actively participated in international research collaborations. His work bridges theoretical and applied engineering, making significant contributions to Indonesia's technological advancement across mechanical vibrations, robotics, renewable energy, and engineering optimization.

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Prof. Nindhia obtained his B.Sc. degree in Mechanical Engineering from Udayana University, Bali, Indonesia in 1997, with joint guidance from the Department of Mechanical Engineering at Sebelas Maret University, Surakarta, Indonesia. He earned his M.Sc. degree in Mechanical Engineering from Gadjah Mada University, Yogyakarta, Indonesia in 1999, supported by scholarships from the Indonesian government, the Van de Venter Foundation of the Netherlands, and the Asian Development Bank. He then obtained his Ph.D. from Gadjah Mada University, Yogyakarta, Indonesia in 2003, with joint guidance from the Department of Metallurgy at the University of Indonesia and funding from the Indonesian government. From 2004 to 2006, he was selected by the Ministry of Foreign Affairs of Japan to receive training at Toyohashi University of Technology, Toyohashi, Japan in the field of Production Systems (Manufacture), where he earned a second M.Sc. degree in Production Engineering. Currently, he is a Professor of Engineering Materials in the Mechanical Engineering Study Program within the Faculty of Engineering at Udayana University in Jimbaran, Bali,

Indonesia. In 2016, the Indonesian government, through the Ministry of Energy and Mineral Resources, awarded Prof. Nindhia the Energi Prakarsa Award. In the same year, he also received the International Bernd Rode Award from the ASEAN-European University Network, along with a funding prize to support research cooperation across Europe.

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Dr. Suryawan, S.T., M.T., is an accomplished academic and engineering professional in Indonesia, holding extensive expertise in engineering and technology. He earned his B.Sc. of Engineering (S.T.), M.Sc. of Engineering (M.T.), and Ph.D. degree through a career marked by a strong dedication to higher education and impactful scientific research. As an active researcher and lecturer affiliated with leading academic institutions in Indonesia, Dr. Suryawan focuses on advancing technological and infrastructural engineering. His professional contributions involve publishing peer-reviewed scientific papers, supervising student theses, and leading engineering projects with industry and government applications. Leveraging a strong background in engineering and technology, he serves as a valuable contributor to Indonesia's technological innovation and structural growth.

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Dr. Suryaningrum, Sp.M., is an ophthalmology specialist based in Bali, Indonesia. She earned her Medical Doctor (M.D.) degree and completed her specialization in Ophthalmology (Sp.M) at the Faculty of Medicine, Udayana University, Bali, Indonesia. Through her advanced clinical education, she gained extensive training in diagnosing and treating complex eye diseases, including cataracts, glaucoma, retinal disorders, and refractive errors. As a specialist, she is affiliated with professional organizations such as PERDAMI (Persatuan Dokter Spesialis Mata Indonesia) and contributes to academic research, teaching, and the publication of scientific papers in ophthalmology. Dr. Suryaningrum practices in hospitals and clinics, providing comprehensive eye care that encompasses medical treatment, advanced surgical procedures, and vision correction. Her profile reflects a deep commitment to advancing eye health in Indonesia through clinical excellence and medical education.

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Mr. Tenaya, S.T., M.T., is an academic and engineering professional from Bali, Indonesia, serving as a lecturer in the Mechanical Engineering Study Program within the Faculty of Engineering at Udayana University. He completed his primary and secondary education in Petang in 1982 and 1985, respectively, followed by high school in Denpasar, Bali, Indonesia in 1988. He earned his B.Sc. of Engineering (S.T.) degree in 1994 from the Department of Mechanical Engineering at Udayana University, Bali, Indonesia focusing his thesis research on “Heat Transfer Analysis of Building Envelopes in Air Conditioning”. During his undergraduate studies, he received a Service Bond Allowance scholarship from 1993 to 1994. He was appointed as a lecturer in 1996 and subsequently pursued his master’s studies at Brawijaya University, Malang, Indonesia where he earned his M.Sc. of Engineering (M.T.) degree specializing in Energy Conversion in 2007. Since completing his advanced degree, he has actively taught in the Mechanical Engineering Study Program at Udayana University, Bali, Indonesia. In addition to his academic roles, he served as a secretary of the Mechanical Engineering Department for the Non-Regular Program from 1997 to 2005, and as a Head of the Electrical Power Engineering Laboratory from 2016 to 2021. His primary research fields include energy conversion, fuel-combustion engineering, and heat transfer.



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