Significance of Artificial Intelligence in ophthalmology: Review Article

Komal Bhaurao kedar[1]*, Shrikrishna K. Nannaware[2], Geeta V. Sathavane[3], Chetan Saoji[4] and Praful Patil[5]

[1] *Assistant Professor Shalakyatantra Department, Datta Meghe Ayurved Medical College and Hospital Wanadongari, Nagpur;* [2] *MD Community Medicine, IGGMC Nagpur;* [3] *Associate professor of Rog Nidana and Vikruti Vigyana Department, Datta Meghe Ayurved Medical College and Hospital Wanadongari Nagpur.*[4] *Assistant Professor Dept. of Ophthalmology Datta Meghe Medical College, Shalinitai Meghe Hospital and Research Centre Nagpur;* [5] *Assistant Professor Dept. of Microbiology Jawaharlal Nehru Medical College, Datta Institute of Medical Sciences Sawangi (Meghe) Wardha.*

Corresponding author: *Dr Komal Bhaurao Kedar, Assistant Professor Shalakyatantra Department, Datta Meghe Ayurved Medical College and Hospital Wanadongari, Nagpur, Tel:7507347061;E-mail: komalnanaware09@gmail.com*

Abstract

In 1959, artificial i ntelligence t echnology h as developed s peedily and supportin scientific analysis and health institute. It is used in ophthalmology for data analysis, separation, diagnosis and possible final o utcomes. A I is being used in ophthalmology for diagnosed Anterior and posterior segment diseases. In Anterior segment disorders such as Keratoconus diagnosed by Topography, Cataract diagnosis, its gradations and intra ocular lens power calculations, refractive errors identify with the help of Snellen charts and appropriate number of refractive error with the help of auto refractometer. Posterior segment disorders like a DR, glaucoma, Age related macular degeneration, Retinopathy of prematurity, Retinal detachment, retinal vascular occlusions, Strabismus, and ocular oncology, Peri-Orbital trauma, organisation of strabismus surgeries, and intra vitreal anti VEGF injections. AI is a well-developed technology in ophthalmology and can detect cerebral impairment, dementia, Alzheimer's disease, stroke risk, papilledema from colour fundus photographs and optical coherence tomography, Fluorescein angiography. In recent year lifestyle of human being has modified drastically with the help of (AI), (ML), and (DL) technologies. AI is multifaceted machinery. Together, AI, ML and DL are look forward to supply computer devices to the ophthalmologists for early distinguished and suitable treatment of ocular disorders in the forthcoming. Imaging modalities in ophthalmology supply methods to diagnosed ophthalmic disorders and detect the development of pathologies including anterior and posterior segment ophthalmic disorders. There are many imaging technology is used for diagnosing ophthalmic disorders such as colour fundus photography, optical coherence tomography (OCT), Fluorescein angiography, indocyanine green angiography, fundus auto fluorescence, corneal topography, slit lamp photography. Extension of average lifespan of human being, changes in lifestyle, demographics, and the changing pathogenesis of much chronic condition such as Obesity, Hypertension, Diabetes, DR, AMD, and Glaucoma produced big a demand for such technology.

Keywords: Artificial I ntelligence; M achine l earning; D eep Learning; Photography study; corneal topography and tomography; OCT

Introduction

In 1956 John McCarthy was first described artificial intelligence (AI) as a technology able to thing alone and recreate human behaviour after training (1). In 1959 Arthur Samuel was introduced Machine learning (ML) as an algorithm instead allow for computers to train on data inputs and use statistical analysis in order to output values that fall within a specific range (2).

It is very important to early recognition and proper management of ocular disorders to prevent avoidable impaired vision and to give better quality of life to the patient. Therefore, together implementations of AI,

ML, DL into ophthalmology has the capability to transform the survive diseased diagnosis system and generate a remarkable advanced effect in ophthalmic health wellness services (3).Deep learning (DL) is known as a subset of machine learning. Neural networks are used in machine learning algorithms. The machine to make its own decisions without human help with the use of neural network. The development of these technologies Neural networks (NNs) play an important role (4). Convolutional layers are important layers, which are the foundation of these network. With the help of convolutional filters to learn abstract the image characteristics (5).Deep learning is used in ophthalmology for data inspection, division, computerised detection and possible outcome in the future (6). A primary benefit of DL in ophthalmology could be in screening DR and ROP, for which well established guidelines exist in textbook. Other conditions, such as glaucoma and AMD, may also require screening and long term follow up with treatment protocol (7). The interconnection of deep learning and optical coherence tomography (OCT) technologies has showed reliable for diagnosed retinal diseases and enhance the diagnostic performance in the posterior segment diseases of eye disease (2).

Day by day number of retinal disorder has increased and it increased requirement for retinal profile readers. The analysis of retinal imaging can reduce the time for profile explanation and the time duration allotted for this procedure due to development of artificial intelligence and deep learning. Due to AI may increase, the success of healthcare providers by establishing the right and fast diagnosis of retinal diseases.

What is AI, ML, DL AND COMPUTER PROGRAMMING:

In 1956 John McCarthy, who define the term Artificial intelligence. In ophthalmology Artificial intelligence technologies entered recently and continue expansion in this field. In the future AI will have support to achieve new research, new discoveries and improving clinical practices[Figure 1].
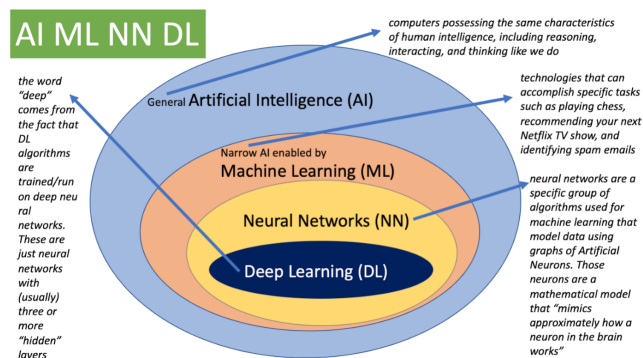
Computer Programming Services

The computer programming has an essential role in world. Programming is using a language. This language that a machine can understand and sin order to get it to perform various tasks. In advanced the software programmer has to know how to process the data to produce the required information. It will generate the required output when the ML software has finished learning (8).

Photographic study:

Several methods of imaging the eyes or selected regions of the eye, using white light or various spectral wavelength of light.

Types –

Documentary photography: colour images of face, external eye, anterior segment and fundus (white light or red free lightening).

Fundus autofluoresence (FAF): Imaging modalities that take advantage of the naturally and pathologically occurring fluorophores in the fundus. Provides sensitive information regarding the health of the retinal pigment epithelium and allows early detection and monitoring of a variety of conditions such as AMD, macular dystrophies, and medication toxicity. It is also useful in the evaluation of certain ocular tumours, choroidal nevi and melanomas.

Specular microscopy: Contact and non-contact photographic techniques used to image the corneal endothelium. It can be used to be evaluate the quantity and quality and of the endothelial cells.

Corneal topography and tomography

Computerised corneal topography is performed using various methods, including placido disc analysis, scanning slit beam, raster stereography. They can provide information on anterior corneal curvature and regularity.

Computerised corneal tomography, it reconstruction of multiple images of cornea may help give detailed information about the anterior, posterior, central cornea. These techniques include anterior segment OCT, scanning slit, and rotating scheimpflug photography based systems. Scanning slit and rotating scheimp flug useful detecting posterior corneal elevation and anterior segment anatomy. It also measures corneal thickness.

It is useful detecting irregular astigmatism secondary to keratoconus. It is also helpful in identify the cause of decreased vision in patient with no known cause, refractive surgical screening and imaging the post keratorefractive cornea.

Optical coherence topography

Optical coherence topography (OCT) is a non-invasive, non-contact imaging system providing high resolution cross sectional images of the posterior segment. OCT machines has inbuilt segmentation of scan is a type of AI(1).OCT images used for diagnosed and understand exact pathophysiology of disease, follow up of treatment route, for assessing the reaction to medicinal, surgical, laser therapy and for the documentation and make clear the pathogenesis and prognosis of a particular disease to the patients. DL

algorithms as device for self-operating reading of OCT profile used for recognize normal and disease image (10).

Applications – (9)

Macula –The diagnosis of macular pathology has been revolutionized by the advent of OCT imaging i.e. AMD, Diabetic maculopathy, macular hole, epiretinal membrane, and vitreomacular traction, CSR and retinal venous occlusion.

Glaucoma – The widespread of OCT in ophthalmology suites for the assessment of medical retinal disease has contributed to its increased adoption as an adjunct to clinical and perimetric assessment in the management of glaucoma.

Retinal Detachments – Distinction of retinal detachment from retinoschisis.

Anterior segment OCT – It has an expanding range of clinical applications such as suspected angle closure glaucoma and corneal analysis such as pachymetry, pre and post refractive procedure, diagnosis, and monitoring.

Automated OCT study has also been helpful in the detection of diabetic retinopathy, CSR, polypoidal choroidal vasculopathy and macular holes, macular plucker, macular oedema, age related macular degeneration, Glaucoma, vitreous traction (10). Obviously, OCT reading algorithms is useful for ophthalmologist to diagnosed the disease and a guide for the treatment and final decision making.

Diabetic retinopathy

The prevalence of DM has raised remarkable in the past several years and disease continue to remain a universal epidemic. Therefore, increased the prevalence of diabetic retinopathy. DR can be examined by different methods like direct ophthalmoscopy (11), Indirect ophthalmoscopy, dilated slit lamp examination with 90D or 78D (12) dilated or non-dilated colour photography (11), and retinal fundus video recording (13).

In current scenario AI is most widely used in ophthalmology. In current, many clinical studies and review has been done with Digital colour fundus photography with its proliferative and non-proliferative classifications (14). The first US Food and Drug Administration-approved autonomous AI diagnostic device was IDX-DR for detecting DR and diabetic macular oedema(15).

Typically, ML systems run on a powerful server computer. Fundus images taken using a fundus camera are collected and evaluated later or they are uploaded through the internet to the powerful server which generates the report and sends it back to the device.(1)

The researcher used software for examine normal retinal images and diabetic retinopathy images and divided into different group like Proliferative and non-proliferative DR, or mild, moderate and severe. The software also able to recognize micro aneurysms, haemorrhages, soft and hard exudates, cotton wool spots and neovascularisation.

Age related macular degeneration

Age related macular degeneration is also known as senile macular degeneration. It is degenerating disorder affecting the macula. It is bilateral disease condition of person over 50 years of age. It is the most common cause of irreversible visual loss in developing countries (16). Patient with moderate vision loss due to non-advanced AMD in one eye or even late AMD in one eye, have about a 50% chance of developing advanced AMD in the fellow eye within 5 years (17).

AI has contributing special role for diagnosed the disease, severity and help both doctor and patient. Digital fundus photography is useful for diagnosed the AMD with its classification i.e. Dry and Wet AMD. Dry AMD the centre of retina deteriorates and wet AMD means leak blood vessels grow under the retina. But OCT provides significant information about haemorrhages, choroidal neovascularization, neovascular membrane, determination of extent of membrane in many cases. Serous retinal detachments, and membrane that are component of exudative macular degeneration and allow a more precise and detailed analysis of anatomic structures and neovascular membrane lesion subtypes.

AI as support to treatment decision making in AMD. AI is important during anti-VEGF(anti-vascular endothelial growth factor) treatment is necessary. Therefore, AI more useful for early detection and management of ARMD into the clinical practice.(18,19)

Glaucoma

Glaucoma, the second most common cause of blindness worldwide, is characterized by chronic progressive optic neuropathy caused by a group of ocular conditions which leads to damage of the optic nerve with loss of visual function. Early diagnosis and treatment of glaucoma is important for preventing avoidable blindness. In ophthalmology glaucoma evaluation done by measuring intraocular pressure, Gonioscopy, Visual field, optic disc cupping, Neuroretinal rim, optical coherence tomography and pachymetry. Pachymetry, the measurement of corneal thickness, in recent year has become an essential part of the assessment of glaucoma patients. OCT has a regular part of the treating macular and other retinal disorders, the same technology can be used for the assessment of the glaucoma and has been widely used for this purpose. Sensitivity and specific utilizing comparison with a normative database are as high as 90%.With the help of OCT peripapillary retinal nerve fibre layer thickness compared with normal, radial cross sectional scan permit an objective and repeatable assessment of disc morphology with reasonable discriminatory value, ganglion cell complex analysis involves measurement of retinal thickness at the macula in an attempt to detect stage glaucomatous damage (20).

Early diagnosis of glaucoma is very important to treat glaucoma early as possible. Glaucomatous structural and quantatively changes find with the help of OCT. With the

help of AI, ML, and DL early automatic detection of glaucoma is possible. In glaucoma, early changes in peripheral vision and it is diagnosed with visual field testing with the help of perimetry. Together AL-,ML-,DL- can diagnosed glaucomatous diagnostic models, fundus photo, OCT study have been used.(21,22,23)

The future

In upcoming future, Artificial intelligence will come to be most involved in the field of ophthalmology for appropriate decision making regarding to ophthalmic examination with investigations, final diagnosis and treatment. Already, IDx-DR is a software program approved by FDA as a low to moderate risk device. IDx-DR uses an artificial intelligence algorithm to analyse diabetic retinopathy and helping the patients that need to referral to an ophthalmologist.

AI can rapidly analyse huge database. AI wide application in ophthalmology and will drastically changes pathway for many diseases such as diabetic retinopathy, ARMD, Glaucoma, corneal ectasias. AI may enlarge the ability of healthcare supplier by prove the right and fast detection of disease. In scientific investigation AI also plays an important role. The feature of just discovered eye disease can be identified with the help of AI. Studies on application of AI in medical and clinical education were reported by Deopujari et. al. (24) and Shrivastava et.al.(25). Other related studies on ophthalmic health problems were reviewed (26-30).

In current many research going on to develop computer programming able to diagnose disease such as AMD, diabetic retinopathy, diabetic macular oedema, retinal detachment, glaucoma, and many more ophthalmic disorders see progression and suggest appropriate management.

Conclusions

Artificial intelligence is very useful in ophthalmology. On-going research aim, with the help of computer programming to diagnosed disease early as possible to avoid complication and help doctor to minimize work load. In ophthalmology, most widely used computer programming for detection of pathophysiology and to treat the patient with the help of Photography study, Corneal topography and tomography, OCT profile.

AI assisted computer screening and diagnosis of the common disease in ophthalmology may ultimately help maximize the doctor's role at the clinic. Outside the clinic, where an ophthalmologist is not available their AI platforms provide more medical circumstances and subsides barrier to access for an eye care. DL has shown important work in the field of ophthalmology clinically detecting retinal disorders such as diabetic retinopathy, retinopathy of prematurity, ARMD, Glaucoma etc. Application of AI make great support to remote area patient by contributing information in limited resources.AI also be applied in clinics to decreased the number of patient's referral in higher centre for further management. In ophthalmic point of view, AI has capability towards patient access to clinical examinations, diagnosis,

managements and affordable particularly in low socioeconomic country. However, AI based screening merge in clinical practices is more important to solve legal and duplicate issues.

References

1. Akkara JD, Kuriakose A Role of artificial intelligence and machine learning in ophthalmology, Prog Retin Eye Res. 2019;31:1-10.

2. Moraru AD, Costin D, Moraru RL, Branisteanu DC, Artificial intelligence and deep learning in ophthalmology – present and future (Review), Prog Retin Eye Res. 2020, 3469-3473.

3. Balyen L, Peto L: Promising Artificial Intelligence–Machine Learning–Deep Learning Algorithms in Ophthalmology, Prog Retin Eye Res May-June 2019; 8:264-727

4. Lee A, Taylor P, Cramer JK and Tufail A: Machine learning has arrived! Prog Retin Eye Res. 2017; 124:1726-1728.

5. Lecun Y, Bengio Y, Hinton G: Deep learning, Nature. Prog Retin Eye Res. 2015; 521:463-444.

6. Erfurth US, Sadeghipour A, Genrendas BS, Waldstein SM and Bogunovic H: Article intelligence in retina. Prog Retin Eye Res. 2018;6:1-29.

7. Ting DSW, et al. Artificial intelligence and deep learning in ophthalmology, Prog Retin Eye Res. 2019;103:167-175.

8. Sayres R, Taly A, Rahimy E, Blumer K, CozD, et al: Using deep learning alogorithum and integrated gardients explanation to assist grading for diabetic retinopathy. Ophthalmology. Prog Retin Eye Res. 2019; 126:552-564,.

9. Gerstenblith AT, c Rabinowitz MP"The wills Eye Manual, office and Emergency Room Diagnosis and Treatment of Eye Disease" , Prog Retin Eye Res.2012; page no. 424-429.

10. Hussain MA, Bhuiyan A, Turpin A, Luu CD, Smith RT, Guymer RH and Kotagiri R: Automatic id entification of pathology distorted retinal layer boundries using SD – OCT imaging. Prog Retin Eye Res. 2017; 64:1638 -1649.

11. Liu YY, Ishikawa H, Chen M, Wollstein G, Duker JS,et.al: Computerized macular optical coherence tomography scan based on multiscale texture and shape features. Invest Ophthalmol Vis Sci. Prog Retin Eye Res.2011; 52:8316-8322.2011.

12. A Hutchinson, McIntosh A, Peters J, et al: Effectivness of screening and monitoring tests for diabetic retinopathy a systemic review. Diabetic Med. Prog Retin Eye Res.2000; 17;495 – 506.

13. Scanlon PH , Malhotra R , Greenwood RH , et al Comparison of two reference standards in validating two field mydriatic digital photography as a method of screening for diabetic retinopathy. Br J Ophthalmol. Prog Retin Eye Res.2003; 87:1258 63.

14. Ting DS,Tay-Kearney ML , Constable I , et al. Retinal video recording a new way to image ana diagnose diabetic retinopathy. Ophthalmology. Prog Retin Eye Res. 2011; 118:158-893.

15. Padhy SK, Takkar B, Rohan Chawla, and Atul Kumar Artificial intelligence in diabetic retinopathy: A natural step to the future. Indian J Ophthalmology. Prog Retin Eye Res 2019; 67(7): 1004-1009.

16. A.K. Khurana, Comprehensive Ophthalmolgy, sixth edition. Prog Retin Eye Res.2015, 295-297.

17. Jack, Kanski, Brad Bowling, Kanskis clinical Ophthalmolgy A Systemic approach, Eight edition, Brand Bowling. Prog Retin Eye Res. 2015, page no 598.

18. Yogesan Kanagasingam, Xiao D, Vignarajan J, et Evaluation of Artificial Intelligence–Based Grading of Diabetic Retinopathy in Primary

19. CareJAMANewOpen. Prog Retin Eye Res. 2018;1(5):e182665.

20. Aslam TM, Zaki HR, Mahmood S, Ali ZC, Ahmad NA, Thorell MR, et al. Use of a neural net to model the impact of optical coherence tomography abnormalities on vision in age-related macular degeneration. Am J Ophthalmol. Prog Retin Eye Res. 2018;185:94-100.

21. Jack, Kanski, Brad Bowling, Kanskis clinical Ophthalmolgy A Systemic approach, Eight edition, Brand Bowling, Prog Retin Eye Res. 2016, page no.- 320.

22. Schmidt-Erfurth U, Bogunovic H, Sadeghipour A, Schlegl T, Langs G, Gerendas BS, et al. Machine learning to analyze the prognostic value of current imaging biomarkers in neovascular age-related macular degeneration. Ophthalmol Retina. Prog Retin Eye Res. 2018;2:24-30.

23. Zheng C, Johnson TV, Garg A, Boland MV. Artificial intelligence in glaucoma. Curr Opin Ophthalmol . Prog Retin Eye Res. 2019; 30:97-103.

24. Martin KR, Mansouri K, Weinreb RN, Wasilewicz R, Gisler C, Hennebert J, et al. Use of machine learning on contact lens sensor-derived parameters for the diagnosis of primary open-angle glaucoma. Am J Ophthalmol. Prog Retin Eye Res. 2018; 194:46-53.

25. Deopujari S, Shrivastava A, Joshi AG, Meshram A, Chaudhary S . "Algoman: Gearing up for the 'Net Generation' and Era of Artificial Intelligence, One Step at a Time." INDIAN JOURNAL OF PEDIATRICS 86, Prog Retin Eye Res. 2019; 86:1079–80.

26. Srivastava, Tripti K., and Waghmare L. "Implications of Artificial Intelligence (Al) on Dynamics of Medical Education and Care: A Perspective Ocr." JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH 14. Prog Retin Eye Res. March 2020.

27. Sharma, Kanika, Kalakoti P, Juneja R, Sahu S, Singh V, et. al. "Re-Emphasizing Thygeson's Warning: Conjunctival Phlyctenulosis as Presenting Sign of Impending Clinical Tuberculosis." CANADIAN JOURNAL OF OPHTHALMOLOGY-JOURNAL CANADIEN D OPHTALMOLOGIE 49. Prog Retin Eye Res. 2014; 6:135–37.

28. Mona SP, Sune PG. "Conjunctival Rotation Autograft for Pterygium: An Alternative to Conventional Conjunctival Autografting." ASIA-PACIFIC JOURNAL OF OPHTHALMOLOGY 2, Prog Retin Eye Res. 2013;2: 227–31.

29. Meenakshi Y, Joharapurkar SR, Bhole AM, Manisha Chawla, Sumit Chopra, and Anup Paliwal. "Orbital Floor Dermoid: An Unusual Presentation." INDIAN JOURNAL OF OPHTHALMOLOGY, Prog Retin Eye Res. 2009; 57:51–52.

30. Sorte K., Sune P, Bhake A, Shivkumar VB, Gangane N, Basak A. "Quantitative Assessment of DNA Damage Directly in Lens Epithelial Cells from Senile Cataract Patients." MOLECULAR VISION. Prog Retin Eye Res.2011; 17:1–6.

31. Goyal MM, Vishwajeet P, Mittal R, Sune P. "A Potential Correlation between Systemic Oxidative Stress and Intracellular Ambiance of the Lens Epithelia in Patients with Cataract." JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH . Prog Retin Eye Res. 2010; 4:2061–67.