

# Artificial Intelligence – A Technological Revolution in Eye Disease Diagnosis

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## Abstract

Artificial intelligence (AI), considered the fourth major industrial revolution is progressing at a very fast pace to affect every aspect of life in the present era, including medical science. In near future it is likely to become a major tool in the diagnosis and management of diseases and to even predict future course of the diseases. This technology by using machine learning (ML) and deep learning (DL) techniques has shown reliable and accurate diagnostic efficacy by analyzing retinal images, optical coherence tomography (OCT) scans and visual field analysis and other patient data, in diseases like diabetic retinopathy, age related macular degeneration, retinopathy of prematurity, glaucoma and many other eye diseases.. The results provided are at par and comparable with the experts. This may prove to be a great telemedicine tool in screening patients for vision threatening diseases even in primary healthcare facilities and making referrals for patients who require intervention by a specialist.

This review describes the role of Artificial Intelligence in Ophthalmology and its current status.

## Keywords:

Artificial Intelligence, Machine Learning, Deep Learning, Retinal Images, Visual field, OCT

Artificial Intelligence (AI), labeled to be the 4th major industrial revolution is a science for making machines smart to perform tasks automatically without human intervention like a self driving car. AI uses various techniques to make such tasks possible, Machine Learning (ML) and Deep Learning (DL) are the major ones. ML means ability of machines to learn to perform certain acts like making inferences and predictions through ML algorithms after data input, e.g., classifying emails as being spam / not spam. DL is a newer fast developing field, a type of machine learning based on deep neural networks to provide solutions such as object detection in images, speech recognition, language translation with high accuracy comparable or sometimes better than human mind.

Artificial Intelligence (AI) is becoming an important tool in medical science in diagnosis and management of diseases, drug interactions, telemedicine and monitoring of patient's status at home. AI has been shown to give better / at par conclusions and interpretations from imaging studies when compared to experts. AI in healthcare is the use of computer software by way of machine learning and deep learning through neural networks to analyse medical data and provide conclusions for a particular set of data which are comparable to human cognition (medical professionals), i.e. AI is an ability of a computer program to function like a human brain for a particular task from deep learning (DL) process. In medical field DL has been successfully applied to medical imaging analysis with strong accuracy in interpretation and diagnosis from radiological images, skin photographs and histopathology slides.<sup>1-4</sup> With advancing digital technology all types of images including diagnostic imaging studies are stored in digital format which can be analysed pixel by pixel by

deep learning algorithms to give accurate interpretation and diagnosis.

In ophthalmology DL is being successfully applied to ophthalmic imaging, mainly fundus photography (retinal images) and optical coherence tomography (OCT), for evaluation and diagnosis of diabetic retinopathy,<sup>5,6,7</sup> retinopathy of prematurity<sup>8</sup> glaucoma<sup>5,9</sup> and age related macular degeneration.<sup>5,10,11</sup> All these diseases require early diagnosis and treatment and long term follow up to prevent irreversible loss of vision. Screening and timely diagnosis of these common diseases which are increasing in incidence require a large number of specialists and financial resources in both, developed and developing countries. With the use of AI it may be possible to screen, refer and monitor patients in primary healthcare facilities by trained paramedical staff and results transferred to specialists for expert opinion and or treatment. Deep learning algorithms are being developed to predict future course of diseases.<sup>12,13</sup>

## Diabetic retinopathy (DR)

With increasing incidence and life expectancy, 8.5% people over 18 years of age have diabetes in the world and are at a risk of potentially blinding diabetic retinopathy which has become a leading cause of vision loss all over the world. In India the prevalence of diabetes is estimated to be 10.9% - 14.2% in urban and 3.0 – 7.8% in rural population over 20 years of age, with a total of 72.96 million adults having diabetes.<sup>14</sup> The prevalence is fast increasing in rural population also who are not aware about retinopathy and also do not have access to ophthalmologist for regular screening for DR. In DR patient may not have symptoms in early stages of the disease and as the

DR progresses it may cause irreversible loss of vision. Hence it becomes important for a diabetic patient to have yearly fundus examination. AI with fundus camera with trained paramedical staff may help in screening and diagnosing DR in early stages and timely referral to specialist for treatment, thus saving the vision. With the help of AI a large number of patients can be screened even in rural areas and benefitted by timely referral to retina specialist for treatment.

Idx Technologies was the first company to get approval from U.S.F.D.A. for its AI diagnostic device, Idx-DR for clinical use to detect diabetic retinopathy.<sup>15</sup> IDx-DR is a cloud server based software which analyses fundus images taken with a fundus camera and provides two types of results: (1) "more than mild diabetic retinopathy detected: refer to an eye care professional" or (2) "negative for more than mild diabetic retinopathy: rescreen in 12 months."

It has been found in a study conducted at Google that general ophthalmologists are less accurate than AI software and retina specialists are not significantly more accurate than AI in diagnosing DR. The efficiency of general ophthalmologist increases with the help of AI and that of retina specialist improves. In future it may even become possible to predict the course of severity of DR in a particular patient and identify such patient who is likely to have higher risk of vision loss and starting treatment before vision loss occurs.<sup>12</sup>

An algorithm developed by Google for diabetic retinopathy and diabetic macular oedema has been tested and is in use at Aravind Eye Hospital, Madurai, India.<sup>6</sup>

### **Age related macular Degeneration**

Age related macular degeneration (AMD) is a major cause of vision loss in elderly population all over the world. It is estimated that >280 million persons may develop ARMD by 2040.<sup>16</sup> Again it requires a large number of ophthalmologists to screen population for AMD and monitor the disease course in people diagnosed and undergoing treatment. DL systems have been developed using Age Related Eye Disease study (AREDS) data for screening and diagnosis of AMD so as to refer them for specialist care. A diagnostic accuracy of 88.4% to 91.6% have been reported using DL system in the diagnosis of AMD.<sup>10</sup>

Optical coherence tomography (OCT) technique has greatly improved the diagnosis and management of macular diseases especially diabetic macular oedema (DMO) and AMD. Moorfields Eye Hospital and Google's Deep Mind Health have developed an AI system which can diagnose fifty types of retinal pathologies including choroidal neovascularisation (CNV), Macular oedema without CNV, drusen, geographic atrophy, epiretinal membrane, vitreomacular traction, full thickness macular hole, partial thickness macular hole, central serous retinopathy and normal.<sup>17</sup> It has been found that performance of this system is at par with experts and can be used by independent practicing optometrists for screening of patients and timely referral.<sup>18</sup>

### **Glaucoma**

Glaucoma is an optic neuropathy due to loss of axons resulting in glaucomatous cupping and erosion of neuroretinal rim. Primary open angle glaucoma is evaluated by measuring

intraocular pressure, visual field analysis (VFA), fundus photographs and OCT of optic nerve head and retina. AI and DL programs have been developed to detect glaucomatous damage using fundus photographs and OCT images.<sup>9, 19</sup> Similarly programmes have been developed to interpret VFA and detect glaucomatous changes with high sensitivity and specificity comparable to that of clinicians.<sup>20,21</sup>

### **Retinopathy of prematurity**

Retinopathy of prematurity (ROP) is one of the major causes of childhood blindness and the incidence of ROP is increasing with better healthcare facilities and increased survival rate of premature children. Trained personnel may not be available to screen all premature children in developing countries and rural areas, in such places digital fundus photography and

telemedicine and AI techniques can be of great help in screening for ROP. AI software have been developed for screening of ROP from fundus images with high diagnostic efficacy.<sup>22</sup>

### **Other diseases**

AI based computing has been shown to diagnose and predict progression of refractive errors in children.<sup>13</sup>

DL based software have been developed to predict cardiovascular and stroke risk from analysing fundus photographs.<sup>23,24</sup>

### **Approval of AI techniques for clinical use**

In United States AI system called IDx-DR has been approved for testing for diabetic retinopathy and is being offered at CarePortMD, the retail health clinics at Albertsons grocery stores, the second largest grocery store chain in United States.<sup>15,25</sup>

**Challenges** – Though AI, DL and machine learning techniques are developing at a very fast pace but most of these models have been developed using data from developed countries with different ethnic populations and geographies, it remains to be tested whether these models provide equally reliable results in populations all over the world. Medico legal aspects and regulatory laws are different in different countries and will require to be considered.

AI, machine learning and DL is progressing at a very fast pace in the field of ophthalmology and will be a major contributing technology in the screening and management of major causes of blindness the world over and particularly in developing countries where super speciality facilities like retina and glaucoma are available in large cities only, the number of which is not enough to examine every diabetic patient for DR or to examine all suspects of other retinal diseases. These techniques if become affordable may of great help to general ophthalmologist and optometrists to triage for presence of retinal pathologies and make referrals for selected patients, in developing countries like India.

### **CONCLUSION**

The AI enabled data processing in healthcare is advancing at great speed and has achieved a level where it can diagnose and predict future course of a disease accurately by analysing digital data from imaging studies and electronic health records.

In future the DL algorithms can give reasons also (The WHY) for arriving at a particular diagnosis. This technology will help in screening population for potentially vision threatening diseases like DR, glaucoma, AMD, ROP and many others at an early stage by using fundus camera and OCT. The prevalence of these diseases is increasing the world over and it is not possible to physically examine every person likely to develop these diseases. For eye diseases a large population can be screened by fundus camera even at a primary healthcare centre /by general ophthalmologist or optometrist and result transferred by telemedicine to the concerned expert or facility for treatment if required. This will lead to reducing workload on tertiary eye care centres and specialists by screening and referring only selected patients who require an

intervention to prevent vision loss and help reducing prevalence of irreversible vision loss especially in developing countries like India.

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