DIGITAL AND TELEMEDICINE APPLICATION IN DIAGNOSTICMICROBIOLOGY

AI-Driven digital diagnostics and online diagnostic tools

ABSTRACT

   Technological advancements have created significant opportunities for improving healthcare, especially through telemedicine and artificial intelligence (AI). These innovations have enhanced the speed and scope of medical interventions, particularly in rural areas, where access to healthcare is often limited. In eye care, conditions like glaucoma and retinal diseases, if left untreated, can lead to permanent blindness. Early diagnosis is crucial for preventing such outcomes. Screening programs in rural communities, combined with digital diagnostic tools and AI, can significantly improve early detection and intervention. These technologies allow for remote consultations and screenings, making it possible to reach underserved populations more effectively. AI can assist in analyzing diagnostic data, ensuring timely identification of at-risk individuals. With increased awareness and early detection facilitated by digital tools, the impact of preventable blindness in rural areas can be minimized, ultimately enhancing eye health outcomes.

  1. Introduction

Artificial Intelligence is a most recent developing computer system helping human intelligence in different perspectives like analysing, recognition, diagnosing and helping in the progression of varied industries. Its advanced and quick developing system is playing a high significant role in the medical and laboratory industry (Angelica C. Scanzera a, 2022). In healthcare, AI is serving a crucial role in screening, management and patient triage (Reid & Eaton, 2019). Most of the AI algorithms have been described for analysis in retinal diseases like diabetic retinopathy, Age related macular degeneration, retinopathy of prematurity, retinal vascular occlusion and retinal detachment and also can be used for describing the condition like glaucoma , Keratoconus, cataract, refractive error, Intraocular lens power calculations and strabismus correction surgeries (J Akkara, 2019).

  Telemedicine is the application of communication and information technologies in the health care system between participants in different locations (zva, 2020). The establishment of telemedicine can drastically reduce the risk of infection of the entire outpatient. Some of the features that are available in telemedicine are like telecooperation, teleconsultation, teletherapy, telemonitoring, teleconference, telediagnostics and telemedical emergency (R Gerbutavicius, 2020).

2.  AI intelligence and its mechanism

        AI technology tries to replicate the ability of cognitive task that are associated with human brain. The enormous technical development of the four factors of Big data, storage and computer power and Global networking on the internet could be branch of deep learning develop (Burgess, 2017). The representation layers which can comprise multitude of successive representation. The learning of these representation layers helps to create a network called as neural network. The deep learning models do not replicate the brain’s capacity but it forms a foundation of mathematical framework for learning the representations (Chollet, 2018).

3. Deep learning and examinations of ocular conditions

1. Glaucoma evaluation

   The structural and functional damage of the optic disc in any glaucoma patients can be detected using OCT [Optical coherence tomography] and digital fundus photography. The main drawback that was found that no significant data were found to compare the intensity of the condition and it directly depends on the expertise of the practitioners (B Al-Bander, 2017)

The DL algorithm for the detection of referable glaucomatous optic neuropathy [GON] based on fundus photography .It is shown that deep learning algorithm can detect the glaucomatous change with high sensitivity and specificity , 95.6% and 92% respectively (Z Li, 2018). Later on the optic disc and blood vessel evaluation served as an important factor for determining the glaucoma status hence the vertical cup disc ratio is estimated from the topographic distributions of haemoglobin and so called Glaucoma discriminant function [GDF] is used to calculate a risk score of glaucoma (NYQ Tan, 2020).

The tele optometric examination used a 14-second Reichert slit lamp video recording to evaluate the anterior segment and the Eidon ultra-widefield retinal photographer to evaluate posterior segment. DFE was completed with 90D biomicroscopy and binocular indirect ophthalmoscopy. Intraocular measurements were taken via non-contact tonometry by an in-person technician for telehealth examination and secondary centres were using Goldmann applanation tonometry for more precision (Sanghera, 2023).

1. Age related macular degeneration and diabetic retinopathy evaluation

    The typical sign of ARMD or Diabetic retinopathy is considered to be accumulation of extracellular deposits between RPE and Bruch’s membrane. The presence of hard or soft drusens are not only seen in ARMD but also seen in other retinal lesions. Thus the development Fundus based DL algorithms based on the age related eye disease study [AREDS] were developed. A deep learning system was built which used AREDS data to develop its system and used Augsburg data set which consist of 5555 fundus images of humans above 55 age group to develop collaborative health research (Grassmann, 2018). A study that performed the effectivity of this algorithm concludes that the system performs comparably to human experts when DR and ARMD are detected simultaneously (González-Gonzalo, 2019)

4. Diabetes retinopathy examination

    Worldwide patients with diabetic mellitus, 75% live in low and middle income countries (K Ogurtsova, 2017). In this scenario, reaching out tertiary and secondary eye centres and early sign detection becomes more difficult to the most common population. Recent advancements in technologies help rural populations in suspecting early diabetic changes in eye and appropriate management can help them to prevent permanent vision loss or retain their functional vision. The technologies like stable , classic non-mydriatic fundus cameras, mobile on vehicle hand mounted diagnostics sets , ultra wide field diagnostic sets, OCT , Portable fundus cameras , smartphone based retinal imaging were used to screen the rural places (Grzybowski, 2021).

Diabetic retinopathy serves as a leading cause of irreversible blindness in the working – age population, and detecting it in earlier stages of life plays a crucial role in preventing the loss of productivity in a mid-age life. The integration of retinal grading offline AI into the smart imaging system has significantly impacted. The two core components of the system include an algorithm that checks the quality of the image and a second DR assessment mechanism that generates detecting DR lesions (Sundaram Natarajan, Astha Jain, Radhika Krishnan, Ashwini Rogye, & Sobha Sivaprasad, 2019).

5. Recent advancements in microscopy

   Recently tremendous advancements have been launched in the biomedical field. The traditional microscopes were bulky, lacked communication capabilities and required more trained professionals to handle and interpret. Instead new technologies like compact 3D- printed devices integrated with internet things IoT for data sharing and cloud computing as well as automated image processing using deep learning algorithms, can address these limitations and enhance the conventional imaging workflow (Alessandro MolaniORCID, 2024). In Ophthalmic diagnosis Smartphone microscopy is much more effective and recommended instead of traditional scans for its more instances and cost effectiveness.

6. Advancements in Ophthalmology screening and diagnostics

     Earlier rural screening and diagnosis were time consuming and had lot of challenges to overcome and in many condition patients may also lose their vision due to these shortcomings (Fenner, Wong, Lam, Tan, & Cheung, 2018). The use of IoMT and cloud technology can make a positive impact remote patients monitoring and early symptom detection. Technologies like ophthalmic fundus cameras attached to smartphones and lens adaptors can used intergrated with AI features to give an instant report of the diagnosis (Maamari, Keenan, Fletcher, & Margolis, 2014).

CONCLUSION

               In conclusion, technological advancements, particularly in telemedicine and artificial intelligence, have revolutionized healthcare delivery, especially in underserved rural communities. These innovations have not only increased the accessibility of medical care but also enhanced the effectiveness of early diagnosis and intervention, especially in critical areas like eye care. By leveraging digital diagnostic tools and AI, healthcare providers can offer timely screenings and consultations, ensuring that conditions such as glaucoma and retinal diseases are detected and treated early. As a result, these technologies hold the potential to significantly reduce the incidence of preventable blindness, improving the quality of life for individuals in rural areas. Ultimately, the integration of these advancements into healthcare systems can transform the future of eye care, making it more accessible and efficient, while also contributing to the overall improvement of public health outcomes.

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