HIGH SCHOOL EDITION
Journal of Student Research
Volume 13 Issue 3 (2024)

Interventions of AI, Diagnostics, Biomedical Advancements in Monitoring Neurodegeneration in Alzheimer's Disease

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ABSTRACT

Technological breakthroughs and scientific advancements have paved the way for neuroscientists and cognitive psychologists to dabble with novel AI and Machine Learning tools towards better detection, diagnosis and comprehensive care for patients diagnosed with neurodegenerative diseases. Researchers have currently been applying new forms of research findings through analyzing AD-related neuropathology utilizing CNN-based systems, through the help of various apps and tech interventions. This research publication will intrinsically entail an analysis of the evaluation of various tech products and bioelectronics that have made it easier for neuroscientists to detect for signs of neurodegeneration, whilst also discussing relevant neurorehabilitation strategies and solutions for the market.

Introduction

Alzheimer's Disease — a neurodegenerative disease that has been associated with significant neural impairments, memory loss and memory loss has been granted a potential source of hope by many researchers through the recent introduction and incorporation of Artificial Intelligence. Through the forms of various deep learning algorithms, researchers have witnessed how CNNs and diagnostic methods have revolutionized the pathology of Alzheimer's disease by creating new clinical solutions, novel biomarkers and analysis of genetic profiles and medical histories to ensure that more patients have accessibility to targeted therapies, which can subsequently improve clinical outcomes. Historically, while research efforts in the early and late 20th century focused upon computerized neuropsychological tests and cognitive tests that have made it easier for researchers and clinicians to detect for AD symptoms, in the recent years, neuroimaging techniques and medical imaging analysis have been revamped through the introduction of novel neuroimaging data, and significant advancements in AI-based diagnostic tools. In the 2000's to early 2010, computational techniques through the help of deep learning algorithms and neuroimaging were made accessible to large-scale analysis and meta-analysis, formulating a more accurate diagnosis and characterization of neurodegeneration through novel AI-driven approaches.

Introduction of AI Algorithms for Early Diagnosis of AD (Machine Learning Techniques)

Research has exemplified how Alzheimer's Disease has been classified as a widespread and prevalent issue, that has especially affected elderly patients aged 65 and above. Thus, in the recent biomedical advancements, new diagnostic algorithms have been created such as through CSF biomarkers like the amyloid beta peptide, which aspen accurately detected in CSF samples of AD patients. (Vrahitis et al., 2023) Intrinsically, researchers identified through implementing CSF markers that cognitive and memory performance levels were correlated

with the levels of CSF markers that are identified in the early stages of Alzheimer's Disease. Thus, through identifying the levels of CSF biomarkers, researchers are able to explore novel forms of cutting-edge technology as well as non-invasive techniques to better diagnose and monitor Alzheimer's Disease through the implementation of complex artificial intelligence methods.

In recent advancements, Lancaster et al. introduced a new form of the "Gallery Game", which has been established as an episodic memory task that serves as a digital biomarker for the detection of Alzheimer's Disease. Researchers identified that data obtained from these sensor-based biomarkers have successfully led the way to employ AI in detecting early-stage deficits in eye movements. (Vrahitis et al., 2023) In conjunction with this, researchers have also paved the way to establish new forms of blood-based biomarkers to better analyze the cerebrospinal fluid through the forms of analytical sensitivity with the help of bio-marker detection. In a recent study, plasma-based primary screening was utilized to better detect amyloid pathology in Alzheimer's Disease.

Adaptation of ML for Detection of Biomarkers that Lead to Higher Susceptibility to Alzheimer's Disease

In digging into the specifics of new diagnostics and biomarkers that can be utilized in precision diagnosis, researchers are able to harness the technological interventions of better assessing and establishing a predictive model to distinguish patients with AD from patients that do not have early symptoms associated with AD. Researchers have been analyzing AD-related neuropathology by analyzing various algorithms that correlate with the different pathological stages. (Chang et al., 2021) For instance, Choi et al. developed a CNN-based automatic image interpretation system that could accurately detect symptoms related to cognitive decline. By implementing this deep learning-based framework, researchers were able to better yield results by identifying the brain regions in the PET images that were most associated with classification results. For instance, a "label-free electrochemical biosensor" has been utilized to better early detect for AD symptoms, by depending upon gold nano-particles that present remarkable results in peptide detection. (Chang et al., 2021) Additionally, through the development of Artificial Intelligence, neuronal injury biomarkers are able to be better analyzed to detect for symptoms surrounding synaptic dysfunction, and in building an optimal predictive model that can help distinguish patients from AD with other populations of patients. Through the formulation of rapid and cost-effective HPLC biomarkers that are developed through machine learning algorithms, physicians in clinical and research settings may be able to better present solutions in outpatient work.

Brain-Computer Interfaces to Aid with Neurorehabilitation

BCI for neurorehabilitation involves the recording and decoding of local brain signals generated by the patient, as he/her tries to perform a particular task (even if imperfect), or during a mental imagery task. The main objective is to promote the recruitment of selected brain areas involved and to facilitate neural plasticity. (van Dokkum et al., 2014) Most rehabilitation tools require some form of motor control, which proves to be insufficient for patients with severe deficits. BCI fills this gap. BCI can therefore be configured such that it maps the decoded brain signals onto useful feedback on the performed task for both patient and therapist. Specifically, BCI induces neuroplasticity, the ability of our nervous system to reorganize its structure, function and connections in response to training. (van Dokkum et al., 2014) However, no BCI application has fully succeeded in being robust in clinical applications. EEG is the most popular technique for BCI applications, due to its fairness, cheapness and non-invasiveness, despite its limitations of the need for a high signal-to- noise ratio. (Mattout et al., 2014)

Analysis of Available Apps and Tech Solutions for Alzheimer's Disease (to Help with Cognition and Memory)

Analysis of Apps

In the app market, there are few apps designed specifically for Alzeihmer's disease. Thus, analysis of tech solutions will be based on dementia, a progressive neurodegenerative condition that can impair memory, thinking, language, orientation, behavior, and the capacity to perform daily activities. This proves to be sensible since Alzeihmer's is one of the many branches of dementia. (Chelburg et al., 2021)

The majority of dementia apps were free to download, but were only available on a single platform, predominantly ios or android. Persons involved in caregiving were the primary audience. App content focused on dementia information, practical caregiving, and communication tips. Language options in addition to English were limited and few apps offered ongoing support. (Chelburg et al., 2021) Persons affected by dementia were provided primarily with apps facilitating brain engagement and cognitive activity.

App	Main functions
MemoClock	1. Reminders from carer to patient
Mindmate	1. Exercise programs 2. Nutrition advice 3. Cognitive simulation
Nymbl	1. Fall risk assessments 2. Balance training tools 3. Digital balance screenings
MyReef 3D aquarium	1. Cognitive simulation
Game Show	1. Memory games
Talking Tom Cat 2	1. Memory Games

Figure 1. Dementia and Cognitive Apps with Highest Usage Amongst Users. Asghar et al., 2016

Analysis of Wearable Devices

Wearable devices that can continuously monitor physiological measures over extended periods, for example in the patient's home, provide unique information not attainable with traditional in-clinic monitoring and hold particular appeal in dementia populations. Advances in technology have made these devices increasingly affordable and user friendly but have been limited by methodological challenges. The primary uses of wearable devices are measuring activity and sleep patterns: ActiGraph activity monitors, which employ an activity-tracking sensor similar to those used in Fitbits and Apple watches.(Cote et al., 2021)

"We tend to think of physical activity as a potential therapy to slow cognitive decline, but this study reminds us that cognitive decline may in turn slow physical activity—and we might someday be able to monitor and detect such changes for earlier and more efficient testing to delay and maybe prevent cognitive impairment that leads to

Alzheimer's," says study lead author Amal Wanigatunga, Ph.D., MPH, assistant scientist in the Department of Epidemiology at the Bloomberg School. (Collins) These wearable devices allow careful measurement of changes of automated, objective measurements of daily physical activity, sleep patterns, heart rate, and blood oxygen levels. While such wearable devices have received formal recognition in its optimal efficacy, researchers are currently working towards better evaluating the prognosis, statistical effectiveness and sustainability of such platforms, which will be delved into in the remainder of this publication.

Evaluation of Wearable Devices, Smartphone Apps and Telemedicine for Patients with Alzheimer's Disease (with an Emphasis on AI-Integration)

Evaluation of Apps

A composite lack of standardized quality indicators and commercial drivers of the marketplace present significant barriers for consumers seeking meaningful dementia information and support. Persons living with dementia and their caregivers would significantly benefit from social and organizational services that assist with navigating the app marketplace.(Chelburg et al., 2021) Furthermore, apps designed for dementia patients are largely limited to cognitive games; few apps present features to facilitate the independence and everyday life conveniences of patients.

Thus, it is encouraged for developers to consider developing apps with simple user interfaces and functions to spread such tech solutions and alleviations from predominantly carers, to patients as well. Governments are encouraged to produce a suitable metric to evaluate the quality and effectiveness of dementia information and support, allowing for a stricter selection of medical advice.

Evaluation of Wearable Devices

Wearable devices, mainly actigraphies, were sufficient in producing insightful results. Results from daily activity and sleep patterns are demonstrated as follows:

Quantitative analysis demonstrated that participants with dementia had a significantly lower mean daytime activity counts compared to controls. This was measured by various statistics: daily activity, peak daily activity, daytime activity, night time activity, number of immobile hours and activity patterns.(Alanna et al., 2021)

Participants with dementia demonstrated reduced sleep efficiency as compared to controls. There was also a significant difference between individuals with dementia and controls on non-parametric measures of circadian rhythm including IV, IS, and RA. Various related statistics were also recorded: wake after sleep onset (WASO) and total sleep time (TST).(Alanna et al., 2021)

Wearable devices display significant comprehension of sleep and motion related statistics, while apps could improve on evaluation metrics and diversifying tailored functions available from carers to patients with Alzheimer's.

Discussion, Ethics, Limitation

In terms of the ethical implications that this may have on the industry, it is crucial to evaluate how these cognitive apps and development lack adherence to proper disclosure, informed consent of patients whose data have been derived. In ensuring that patients with neurodegeneration have access to proper devices, many have been immobilized, or have speech impairments, lacking the proper ability to signify whether they would like to work with devices or not. Additionally, one potential weakness associated with this is that some of these results that

were deduced stem from 2014-2016, when biomedical advancements were limited. Lastly, for incoming research studies, experimental research and empirical findings derived from longitudinal courses of research may be optimal, to ensure that these limitations are addressed, as some of the studies' findings are derived not from longitudinal studies, but merely from 1-time data collection inputs, which lack the ability to diversify such subset of results.

Conclusion

In conclusion, it is evident that there have been significant technological and medical breakthroughs that have made it easier for scientists to better detect and manage the onset of neurodegenerative diseases like Alzheimers, by collecting relevant data points into biomarkers, and image systems that can help track the brain regions responsible for cognition and memory. While these results are essential for future researchers, in terms of cognitive, technological and neurological implications on future researchers, it is essential to deduce that such wearable devices that monitor physiological measures require significant advancements in the years to come, where scientists may need to look into the long-run sustainability of these models and platforms, where both patients and caregivers can benefit equally from the quality and effectiveness of these platforms.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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