Artificial intelligence for epilepsy diagnosis

Artificial intelligence for epilepsy diagnosis is becoming a transformative tool in the management of epilepsy. Here's an overview of how AI is applied in this field:

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1. Diagnosis of Epilepsy - **EEG Analysis:** AI algorithms, especially deep learning models, are used to automatically analyze electroencephalogram (EEG) recordings. These systems can detect abnormal patterns, including epileptiform discharges, with higher sensitivity and specificity compared to traditional manual review.

1. **Advantage:** Reduces the burden on neurologists by quickly identifying potential seizure events in large datasets.

- **Seizure Detection:** Wearable devices equipped with AI can monitor physiological signals like brain activity, heart rate, and movement to detect real-time seizures, providing continuous monitoring for patients outside clinical settings.

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2. Classification of Seizures - **Machine Learning Models:** AI can classify seizures based on type, location (e.g., focal or generalized), and duration by analyzing EEG data and neuroimaging results. This helps in tailoring personalized treatment plans.

- **Natural Language Processing (NLP):** Used to extract relevant information from clinical notes and electronic health records to support seizure classification and decision-making.

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3. Predicting Seizures - **Seizure Prediction Models:** AI-powered prediction models analyze patterns in EEG data and other physiological signals to anticipate seizures, often providing a warning window for patients.

1. **Technology Used:** Recurrent neural networks (RNNs) and long short-term memory (LSTM) networks are particularly effective in temporal pattern recognition.

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4. Integration with Imaging - **MRI Analysis:** AI enhances the detection of structural abnormalities in brain imaging, such as lesions or cortical malformations, that might be missed during manual review.

1. **Specificity in Epilepsy:** AI can pinpoint subtle abnormalities in regions like the hippocampus, aiding in identifying candidates for surgical intervention.

- **Functional Imaging:** Integration of AI with PET or fMRI data helps localize seizure onset zones.

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5. AI in Personalized Treatment - **Medication Response Prediction:** Machine learning models analyze patient data to predict which anti-epileptic drugs are most likely to be effective.

- **Surgical Outcomes:** AI can predict the success of epilepsy surgeries by integrating imaging, EEG, and clinical data, helping guide patient selection for procedures like temporal lobe resections or deep brain stimulation (DBS).

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6. Long-Term Management - **Mobile Apps and AI Assistants:** AI-powered apps provide real-time seizure tracking, medication reminders, and data sharing with healthcare providers.

- **Quality of Life Assessment:** AI tools analyze patient-reported outcomes to adjust treatment plans and improve overall care.

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Challenges and Considerations - **Data Quality:** AI systems require large datasets with high-quality, annotated data for training. - **Ethical Concerns:** Privacy and security of patient data need to be maintained. - **Clinical Validation:** AI models must undergo rigorous validation in diverse populations to ensure generalizability. - **Integration with Clinical Workflow:** Effective adoption requires AI systems that are user-friendly and seamlessly integrate into clinical workflows.

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AI is revolutionizing the field of epilepsy diagnosis and management by improving accuracy, speed, and patient outcomes. As AI tools continue to evolve, they hold promise for reducing diagnostic delays, enhancing seizure control, and enabling personalized care.

Retrospective observational studies

Chiang et al. developed an enhanced epilepsy diagnosis system by integrating an expert-informed ontology with a custom generative pre-trained transformer (GPT), validated by inferring possible seizure lateralization and localization using retrospective textual data from the pre-surgical assessments of patients with pharmaco-resistant epilepsy (PRE).

Artificial intelligence for epilepsy diagnosis using Protégé with OWL/SWRL, integrating a knowledge base with seizure semiology, seizure types EEG descriptors, expert insights, and literature to pinpoint seizure locations. A customized GPT model was then tailored for specific diagnostic needs. Validated through 16 surgical cases, the system's accuracy in seizure localization and the JSON (JavaScript Object Notation) Epilepsy Matcher's term matching capabilities were confirmed against a Protégé-based knowledge base.

117 patients with PRE underwent video-EEG monitoring at a single institution. However, only 16 of these patients received epilepsy surgery. The Protégé system achieved 75 % accuracy in diagnosing epilepsy from 16 cases using semiology, which increased to 87.5 % with EEG data. The JSON Epilepsy Matcher further improved accuracy to 87.5 % with symptoms alone and 93.8 % when including EEG data, highlighting the benefits of applying GPT techniques.

This study highlights the efficacy of the JSON Epilepsy Matcher in improving seizure diagnosis accuracy. When combined with EEG data, it achieves a 93.8 % accuracy rate, suggesting a potential improvement in the practicality and generalizability of the original ontology expert system, boosting

physicians' confidence in confirming surgery and potentially sparing many children from prolonged suffering. This innovative approach not only improves diagnostic accuracy but also sets a precedent for future applications of Artificial Intelligence in Neurosurgery [1)]

Chiang et al.'s work is a noteworthy step forward in applying AI to epilepsy diagnosis and neurosurgery, achieving impressive accuracy improvements by combining ontology and GPT techniques. However, the study’s reliance on small sample size and limited exploration of practical integration and ethical considerations temper its immediate applicability. With further validation, this approach has the potential to revolutionize epilepsy care and inspire broader applications of AI in other medical domains.

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Chiang KL, Chou YC, Tung H, Huang CY, Hsieh LP, Chang KP, Kwan SY, Huang WY. Customized GPT model largely increases surgery decision accuracy for pharmaco-resistant epilepsy. J Clin Neurosci. 2024 Dec;130:110918. doi: 10.1016/j.jocn.2024.110918. Epub 2024 Nov 13. PMID: 39541652.