IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Mindspirit Game Centric Website For Cognitive Training And Progress Tracking In Alzheimer's Patients

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Abstract: Alzheimer's disease is having a growing impact on the global senior population, with the World Health Organization reporting that over 55 million people are affected by dementia of which 60 to 70 percent are Alzheimer's cases. In India alone, more than 4 million people live with the disease, projected to double by the year 2030. With one new case reported every three seconds and global care expenses exceeding $1.3 trillion annually, there is an urgent demand for scalable and efficient interventions.

Alzheimer's disease (AD) is a gradual neurodegenerative condition marked by memory impairment, cognitive deterioration, and alterations in behavior. Timely and precise diagnosis is essential for patient management, treatment strategy, and involvement in research. At present, diagnosing Alzheimer's depends on a mix of clinical assessment, neuropsychological examinations, and neuroimaging methods. Conventional diagnostic methods involve thorough patient history, cognitive evaluations like the Mini-Mental State Examination (MMSE) or Montreal Cognitive Assessment (MoCA), and a neurological assessment. significant family history or symptoms that appear early. A multidisciplinary strategy that integrates clinical, biochemical, and imaging information continues to be essential for effectively diagnosing Alzheimer's disease.

This game features a variety of cognitive challenges, including quizzes and puzzles, designed to enhance focus, memory recall, and problem-solving skills in a simple and interactive way. Additionally, the platform incorporates EEG (Electroencephalogram) technology to monitor the brain's electrical activity during gameplay. This enables the system to deliver immediate cognitive feedback and automatically adjust the difficulty level based on the user's mental responsiveness. By merging brain-training tasks with EEG-based monitoring, our solution offers a comprehensive tool for cognitive rehabilitation and progress evaluation. The aim is to foster greater mental engagement, delay further cognitive decline, and give caregivers and healthcare providers valuable data on the patient's mental performance and development over time.

Index Terms – Alzheimer's disease, Cognitive training, Brain games, Memory improvement, Progress monitoring, Mental health tracking.

I. INTRODUCTION

Alzheimer's disease is a progressive neurodegenerative disorder that primarily affects memory, thinking skills, and cognitive functioning. It is one of the leading causes of dementia worldwide and poses a significant challenge not only to patients but also to families and healthcare systems. As the global population continues to age, the prevalence of Alzheimer's disease is projected to increase rapidly, creating an urgent need for innovative, accessible, and personalized interventions that can slow cognitive decline, improve quality of life, and support early-stage rehabilitation. Traditional pharmacological treatments often provide limited relief and do not significantly alter the progression of the disease. This gap has created an opportunity for digital health technologies and brain–computer interface systems to emerge as complementary tools in the management of Alzheimer's disease.

MindSpirit Game is designed to address this critical healthcare challenge by combining cognitive training through interactive gaming with advanced neurofeedback obtained from electroencephalogram (EEG) signals. Unlike conventional brain training applications, MindSpirit Game integrates both software and hardware components to create a holistic system where patient performance in games is not only tracked digitally but also validated through neurophysiological responses. This dual approach provides deeper insights into cognitive engagement and brain activity, making the system more reliable and clinically relevant. Research has consistently demonstrated that cognitive training exercises, such as memory games, problem-solving tasks, and attention-based challenges, can help in maintaining or even improving certain aspects of cognitive functioning in individuals with dementia. These interventions encourage neuroplasticity—the brain's ability to reorganize and form new neural connections—which is crucial in counteracting the loss of synaptic activity seen in Alzheimer's patients. Traditional cognitive therapies, however, often require frequent in-person sessions with specialists, which can be time-consuming, costly, and inaccessible for many families.

Digital cognitive training platforms offer a solution by making such interventions available at home in an engaging, interactive, and cost-effective manner. Gamification of therapeutic exercises ensures higher patient motivation and adherence, which are critical factors for long-term effectiveness. By embedding these exercises within a structured website, caregivers and healthcare providers can monitor progress over time, enabling early detection of decline and timely intervention.

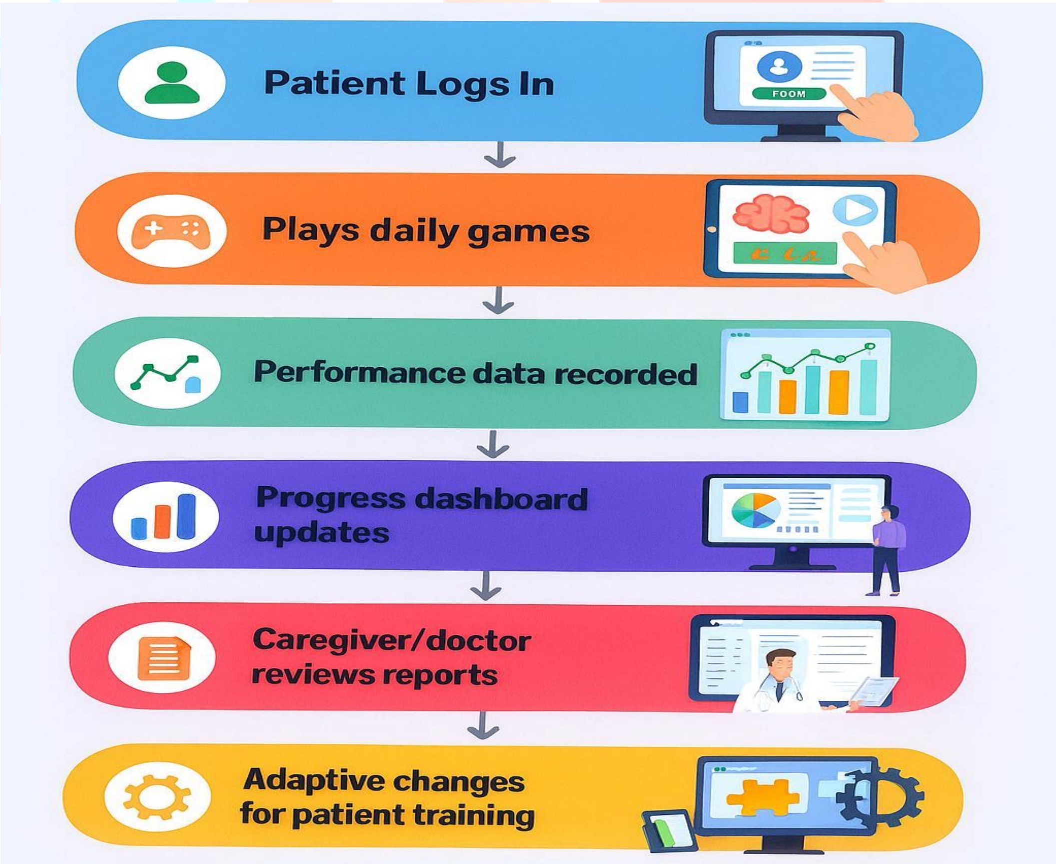
While cognitive games provide useful data on performance and progress, they primarily measure behavioral outcomes such as scores, reaction times, or accuracy. These outcomes, although valuable, may not fully capture the underlying brain activity that reflects cognitive effort and engagement. This is where EEG technology becomes vital. EEG is a non-invasive method of recording electrical activity of the brain through sensors placed on the scalp. It provides real-time insights into brainwave patterns associated with states such as relaxation, attention, memory load, and stress. By recording EEG signals before and after gameplay, MindSpirit Game enables objective assessment of whether the cognitive training exercises are actually stimulating brain activity in meaningful ways. For example, an increase in certain frequency bands (such as alpha and beta rhythms) may indicate improved attention and mental engagement, while reduced abnormal slow-wave activity could reflect positive cognitive changes.

Integrating EEG into our system allows for a unique neurofeedback mechanism. Patients' brain responses can be compared with their game performance, creating a multi-dimensional progress tracking model. This approach helps distinguish between cases where performance improvement may be due to learning the game mechanics versus genuine cognitive enhancement. Moreover, EEG analysis can guide personalization of the training programs by adapting difficulty levels or selecting specific games based on the patient's brain activity profile.

II. METHODS

The methodology of the MindSpirit Game project integrates both hardware and software components to provide a comprehensive cognitive training and progress tracking system for Alzheimer's patients. On the hardware side, a portable, non-invasive EEG headset is used to record brain activity before and after gameplay, with electrodes placed according to the 10–20 system to capture signals from regions involved in memory, attention, and cognitive processing. The raw EEG signals are preprocessed to remove noise and artifacts using band-pass filtering, notch filtering, and artifact rejection techniques, followed by feature extraction to analyze power spectral densities across theta, alpha, and beta bands, which correspond to attention, engagement, and cognitive load. These neurophysiological measurements are then correlated with behavioral data collected from the software component, creating a dual-layer assessment of cognitive function.

The software component consists of a web-based platform that hosts interactive cognitive games designed to target memory, attention, problem-solving, and visual-spatial skills. Patients access personalized accounts to play these games, and real-time performance metrics such as accuracy, response time, and score progression are recorded. The system integrates the EEG data with these performance metrics to provide a comprehensive view of cognitive engagement and improvement. All collected data are securely stored in a central database, and a web dashboard visualizes both game performance and EEG-derived insights, allowing caregivers and clinicians to monitor progress over time. The platform also employs adaptive algorithms that can adjust game difficulty based on performance trends and EEG feedback, ensuring personalized and engaging cognitive training tailored to the patient's current mental state.



III. EXISTING METHODOLOGY

- **Pharmacological Treatments:** Currently, medications such as cholinesterase inhibitors (Donepezil, Rivastigmine, Galantamine) and NMDA receptor antagonists (Memantine) are prescribed to manage cognitive symptoms like memory loss and confusion. These drugs help in maintaining levels of neurotransmitters in the brain to improve communication between neurons. However, their effects are often temporary and modest, and they do not stop the progression of the disease. In addition, some recent advancements in disease-modifying therapies, such as monoclonal antibodies targeting amyloid-beta have shown promise, though their accessibility and long-term benefits remain under evaluation.

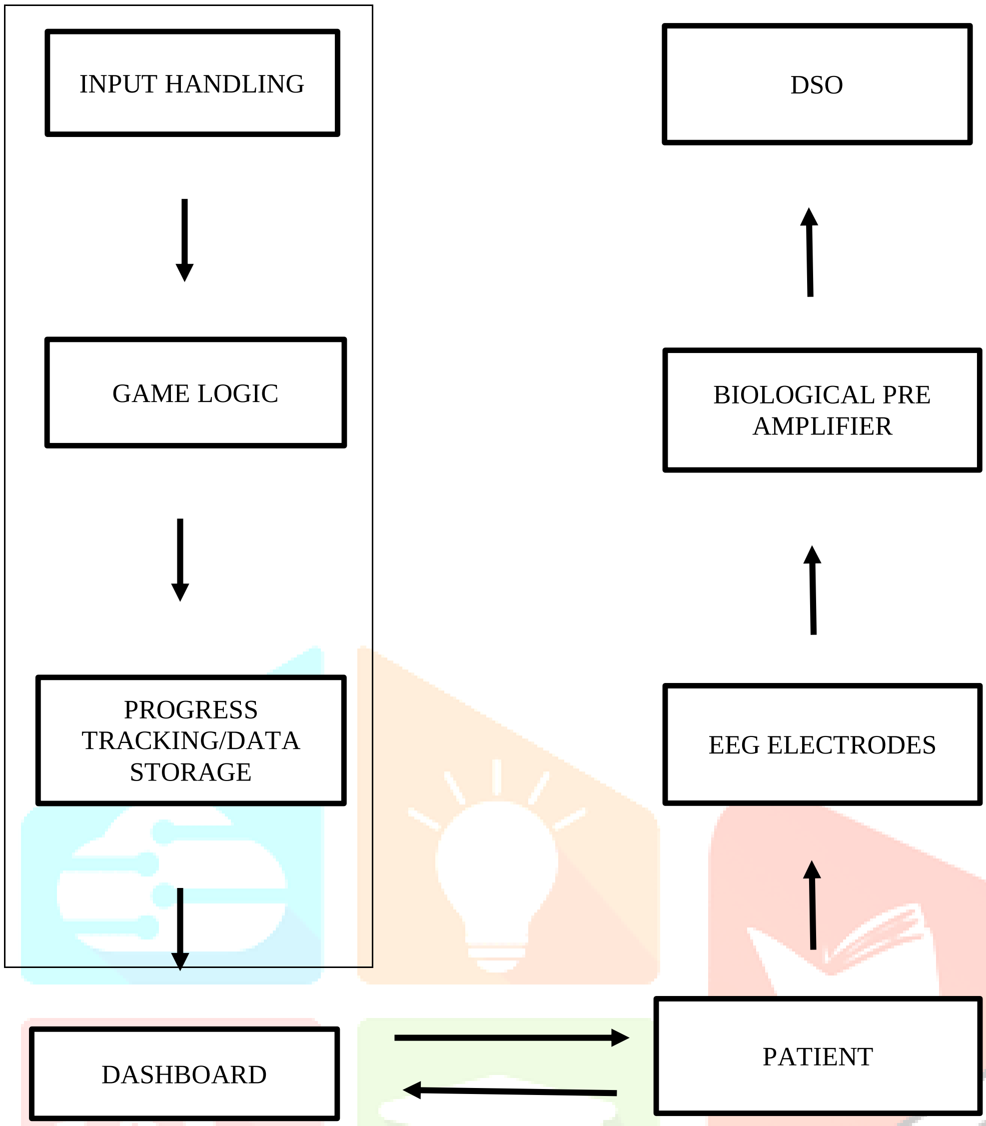
- **Cognitive Training and Rehabilitation:** Cognitive stimulation therapies (CST) are widely used in clinical and community settings. These involve structured group sessions or individual exercises focusing on memory, problem-solving, language, and attention. Activities may include puzzles, storytelling, or memory recall exercises. Digital platforms and mobile applications have also been introduced to make these exercises more engaging and accessible. However, most of these digital solutions rely only on performance scores and lack integration with objective neurophysiological data such as EEG, which limits their ability to validate actual brain engagement.

- **Behavioral and Psychological Interventions:** Since Alzheimer's often leads to behavioral symptoms such as anxiety, depression, aggression, or agitation, behavioral therapy and counseling are employed to improve emotional well-being. Techniques include reminiscence therapy (discussing past experiences), music therapy, art therapy, and relaxation methods. These therapies are non-invasive and often enhance quality of life by reducing stress and increasing social interaction.

- **Physical and Lifestyle Interventions:** Studies have shown that regular physical activity, proper nutrition, and sleep management play an important role in slowing cognitive decline. Interventions such as aerobic exercise, yoga, and meditation are integrated into daily routines to enhance overall brain health. Lifestyle modification is often recommended alongside other therapies to promote neuroplasticity and reduce risk factors associated with cognitive decline.

- **Caregiver Support and Monitoring:** Since Alzheimer's patients become increasingly dependent, caregiver support is crucial. Current methods include structured caregiver education, remote monitoring using wearable devices, and support groups. Some platforms provide digital tracking of patient behavior and daily activities, but these primarily monitor external behaviors rather than internal brain activity.

IV. BLOCK DIAGRAM



V. COMPONENTS

Hardware used

- Hantek DSO5072P
- Pamtrons SKRIP-ECEMG-A SE2173
- Electrodes
- Connecting wires and leads

Software used

- Visual studio code
- GitHub
- Replit

Hardware components

1.Hantek DSO5072P

The Hantek DSO5072P is a dual-channel digital storage oscilloscope designed to measure and visualize electrical signals in the time domain. It features a bandwidth of 70 MHz, a real-time sampling rate of 1 GSa/s, a memory depth of 40k points, and an input impedance of 1 MΩ with ~20 pF input capacitance. Its vertical sensitivity goes as low as 2 mV/div, which is crucial for observing
small-amplitude biosignals when amplified. The oscilloscope digitizes signals with 8-bit resolution, sufficient for capturing basic EEG rhythms (0.5–40 Hz) after preamplification. In this project, it is used as the display and measurement unit to observe EEG waveforms in real time. While it has far greater bandwidth than required for EEG, its fast sampling ensures accurate capture of slow brain rhythms, and its adjustable timebase allows detailed analysis of changes in brain waves during gameplay.

2.Pamtrons SKRIP-ECEMG-A SE2173

The Pamtrons SKRIP-ECEMG-A SE2173 serves as the front-end amplifier that conditions EEG signals before they are viewed on the oscilloscope. Raw EEG voltages at the scalp are extremely small (10–100 µV) and highly vulnerable to interference, making direct measurement impossible. This preamplifier is designed with very high input impedance (typically >100 MΩ) to avoid loading the electrodes, and a high common-mode rejection ratio (≥80 dB) to suppress mains noise and motion artifacts. It provides substantial gain in the range of 100–10,000×, boosting microvolt-level signals into the millivolt range suitable for oscilloscope input. Additionally, it incorporates a band-pass response tailored to biopotentials (around 0.1–100 Hz for EEG), filtering out DC drift and high-frequency noise. Most importantly, it includes isolation circuitry to protect the subject from any current leakage, ensuring patient safety while interfacing with bench-top instruments.

3.Ag/AgCl Scalp Electrodes

The electrodes used for EEG recording are silver/silver-chloride (Ag/AgCl) Electrodes, which are the clinical standard because of their stable electrochemical properties and low noise. These electrodes convert ionic currents in the skin into electrical signals that can be detected by the amplifier. They are typically cup shaped or adhesive with a conductive surface area of ~10 mm, and are used with electrolyte gel or paste to reduce contact impedance. For accurate EEG, the electrode–skin impedance should be kept below 5–10 kΩ through proper skin preparation (cleaning and mild abrasion). Ag/AgCl electrodes offer minimal polarization and low half-cell potential, allowing stable recordings over long periods. In this setup, they provide the interface between the human scalp and the electronics, ensuring that weak brain signals are faithfully transmitted to the preamplifier.

4.Connecting Wires and Leads

The connecting wires link the scalp electrodes to the preamplifier and then route the conditioned signals to the oscilloscope. In EEG applications, specialized shielded leads with low capacitance are preferred to minimize external electromagnetic interference, especially from 50/60 Hz mains supply. Color-coded, medically standard, touch-proof connectors are used for safety and to maintain consistent electrode placement based on the international 10–20 system. The short length and shielding of these leads reduce motion artifacts and cable induced noise, ensuring clean signal transmission. They play a critical role in preserving the fidelity of the weak EEG signals between the scalp electrodes and the amplifier, making them essential despite being simple passive components.

Software components

1.Visual Studio Code :

For our project, we decided to use Visual Studio Code (VS Code) as our primary development environment, and it turned out to be one of the most important tools that supported us throughout the entire process. As a team, we were looking for software that was not only free and reliable but also flexible enough to handle different programming languages and frameworks that our project required. VS Code met all of these needs and provided us with a smooth, professional coding experience. One of the biggest reasons we used it was its ability to instantly highlight errors and provide real-time suggestions through IntelliSense. This helped us avoid unnecessary delays caused by small coding mistakes and improved the overall efficiency of our teamwork. The integrated terminal in VS Code was another major advantage for us, since it allowed us to run our code and test different sections without leaving the editor, saving us time and effort. We also appreciated the fact that VS Code supports a wide range of extensions, which made it easy for us to customize the environment according to our project's needs. For example, we could add extensions for HTML, CSS, and JavaScript formatting, as well as Git integration for version control. This made collaboration much easier, since we could all work on the same codebase, track changes, and manage updates in an organized way. The interface of VS Code was simple but powerful it allowed us to keep our workspace clean while still giving us access to all the necessary features. The ability to switch between different themes and layouts also made long coding sessions less tiring.

2.Replit

For hosting and sharing our project, we chose to use Replit, an online Integrated Development Environment (IDE) that allows users to write, run, and share code directly through a web browser. While Visual Studio Code was our primary tool for writing and debugging the code on our systems, Replit played an equally important role by helping us transform our local project into an accessible, shareable web application. One of the main reasons we decided to use Replit was its ability to instantly generate a live link for our project. This allowed us to easily share the Alzheimer's cognitive game (MindSpirit) with others—team members, mentors, or evaluators—without the need for complex deployment steps or server setups. Instead of manually hosting our project, Replit gave us a ready-to-use environment where everything was configured for web development. We began by creating a new project (also called a "repl") in Replit. Within this environment, we added the three main files that made up our application: index.html, styles.css, and script.js. The index.html file defined the structure and layout of the game, the styles.css file provided the design and visual appeal, and the script.js file contained the game's logic, interactivity, and analytical functions. Replit's file management system made it easy to upload and organize these files, keeping everything clear and consistent, just like in a professional development workflow. Another major advantage was the built-in preview feature, which allowed us to instantly see how our web page looked and behaved while we made changes to the code. This gave us the opportunity to test the interface, correct layout issues, and refine the styling before sharing the final version. By using Replit, we were also able to work collaboratively. Since it is a cloud-based platform, we could access our project from anywhere, and multiple members could view or edit the code without worrying about compatibility issues across different systems. The platform automatically updated the live preview whenever we modified the code, which helped us ensure that the game was running smoothly at all times. Once we were satisfied with the final design and functionality, Replit generated a shareable link for our project. This link served as an easy way to demonstrate our game in action, whether it was during presentations, evaluations, or peer feedback sessions.

VI. RESULT AND DISCUSSION

The results of the bio impedance-based detection system for ovarian cancer demonstrate the potential effectiveness of using electrical impedance as a diagnostic tool. During testing, simulated tissue phantoms were used to mimic the electrical characteristics of both healthy and cancerous ovarian tissues. The system, powered by a 5V source, utilized the AD9833 signal generator to provide a frequency sweep signal, which was then introduced to the tissue via Ag/AgCl electrodes. The resulting impedance response was captured, amplified using the INA128 instrumentation amplifier, converted to digital format by the ADS1115 ADC, and processed through the Arduino UNO microcontroller. Notably, cancerous tissue phantoms exhibited significantly lower impedance values compared to their healthy counterparts, especially at lower frequencies, which is consistent with the physiological differences in cell structure and water content. The system's LED alert mechanism effectively signaled when the impedance dropped below a predefined threshold, indicating the presence of abnormal tissue. These outcomes confirm that bio impedance measurements can be a viable, non-invasive method for early detection of ovarian cancer. However, factors such as electrode placement, contact quality, and signal noise influenced the accuracy of readings. With further refinement and clinical validation, this system could be a cost-effective diagnostic tool in resource-limited settings.

VII. CONCLUSION

The development and implementation of the bioimpedance-based system for the detection of ovarian cancer have demonstrated a promising approach to non-invasive, early-stage diagnosis. This project successfully integrates several key hardware components such as the AD9833 signal generator, INA 128 instrumentation amplifier, ADS1115 ADC, Ag/AgCl electrodes, Arduino UNO microcontroller, and a basic LED alert system to measure and analyze the electrical impedance of tissue samples. By leveraging the principle that cancerous and healthy tissues exhibit distinct impedance profiles due to differences in cellular structure and extracellular fluid content, the system has shown that it can reliably detect abnormalities indicative of ovarian cancer. Throughout the testing phase, it was observed that cancerous tissue phantoms consistently presented lower impedance values, especially at lower frequencies. This correlates with the physiological changes occurring in malignant tissues, such as increased ion concentration and disrupted cell membranes, which lead to enhanced electrical conductivity. The use of frequency-dependent impedance analysis allowed for greater accuracy in distinguishing tissue types. The real-time monitoring and alert mechanism, using an LED to signal impedance anomalies, provided an immediate and understandable output that can be useful in practical clinical scenarios. The simplicity and affordability of the system are among its greatest strengths. Using readily available, low-cost components, we have developed a device that has the potential to be deployed in low-resource settings where access to conventional diagnostic tools like MRI or CT scans may be limited. Moreover, the portability of the hardware makes it suitable for use in remote or rural healthcare environments, thereby enhancing the reach of early cancer detection programs. However, it is important to acknowledge the limitations encountered during the development of this project. One of the main challenges was ensuring consistent electrode contact, as any variability in placement or skin condition could significantly affect impedance readings. Additionally, environmental noise and interference posed difficulties during signal acquisition, though these could be mitigated through improved shielding and signal filtering in future versions. Another critical area for future work is clinical validation. While the system performed well on tissue-equivalent phantoms, testing on real biological tissues and patient samples is necessary to fully assess its diagnostic accuracy and reliability. In conclusion, this project serves as a strong proof of concept for using bio impedance analysis in the early detection of ovarian cancer. It combines medical insight with engineering innovation, resulting in a system that is not only functionally effective but also economically and logistically viable. With further refinement, such as integrating a more advanced signal processing algorithm, increasing the sensitivity of the system, and performing clinical trials, this technology could be scaled into a medically approved diagnostic tool. The potential impact is significant-early detection of ovarian cancer could drastically improve survival rates, and a portable, low-cost device could make such detection accessible to women in all parts of the world.

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